ELECTRICAL ENGINEERING

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The Cover: The 120,000-pound cast steel Francis runner being checked in Allis-Chalmers shops is for the seventh 57,500-hp 112-foot head 85.7-rpm hydraulic turbine for Fort Randall Dam near Pickstown, S. Dak. The completed plant will contain eight identical hydraulic turbines which will draw water through 22-foot diameter inlets from the 6,300,000 acre-foot Fort Randall Reservoir.

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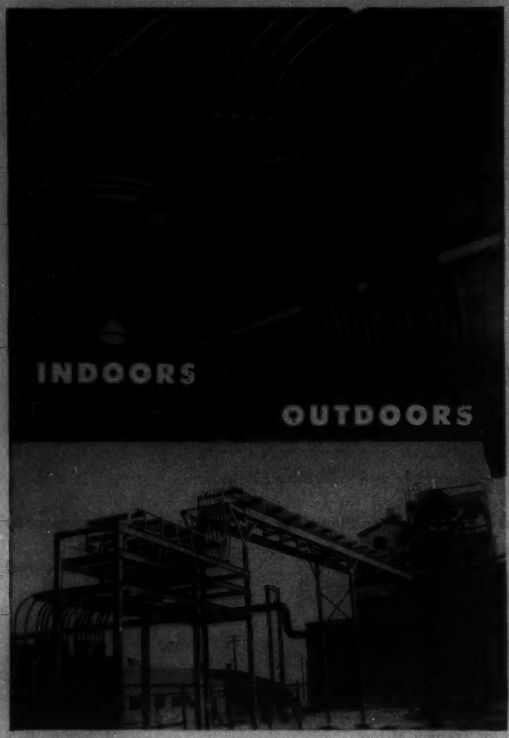

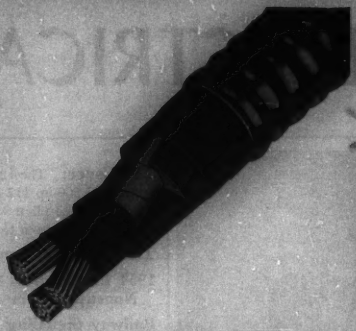

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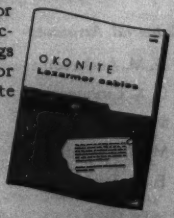

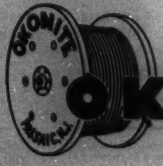

Available with either copper or aluminum conductors

OKONITE SINCE 1878 ***insulated cables***

2978

HIGHLIGHTS .....

Science of Commonplace Things. Like the old Persian farmer in the legend who wandered over the world seeking diamonds when they were to be found in his own back yard, all too often we are tempted to neglect the commonplace and familiar in favor of new and glamorous fields. However, under modern scientific research methods, many everyday phenomena have been made to yield exciting new properties—such as new silicon uses, solar power, and actual man-made diamonds (*pp. 753–8*).

1954 Employment Questionnaire. Since interest has been expressed in a comparison of the answers by supervisors and nonsupervisors to the 1954 employment questionnaire, a cross-analysis between Questions 3 and 7 to 11 of the original questionnaire has been conducted. The results are depicted in diagram form (*p. 759*).

Power System, Arnold Engineering Development Center. This Center's distribution system has been operating since October 1952. Since then one test facility has been put into full operation, another is undergoing calibration, and a third will begin shakedown before the end of 1955. The system has proved well able to fulfill its requirements and it is sufficiently flexible to be modified to meet future demands (*pp. 771–4*).

Automation—A Survey. The immediate future of automation depends on the importance that the designers put on economical design and their use of reliable components. Thus much work has been done on checking methods, and in means for detecting incipient failures. Various types of automation are described, and where each type is being used in industry today (*pp. 775–80*).

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Railway Signaling. Today a railway signal system must be based on properly designed fail-safe circuits. However, under the guidance of a signal engineer, the more conventional communications circuits may then be superimposed and the remote control of railway traffic achieved with complete safety. A specific installation is used to illustrate this principle (*pp. 760–5*).

Fall General Meeting. A preliminary program of the activities for the AIEE Fall General Meeting to be held October 3–7, at the Morrison Hotel in Chicago, Ill., is included in this issue (*pp. 816–21*).

Magnetic Elements in Arithmetic and Control Circuits. The square-loop ferromagnetic core offers the advantages of a considerable reduction in weight, power, and size as well as increased reliability of many parts in information-processing systems. It also shows promise of expanding into the industrial control and communications fields (*pp. 766–70*).

Modern Electric Power Shovels. Rather than presenting the exacting details and the many complexities involved in the application of electric equipment to modern fully electric shovels, the emphasis is placed on making available experiences and information of general interest to all electrical engineers (*pp. 782–7*).

Distribution-Substation and Primary-Feeder Planning. The system planning methods discussed are especially applicable to urban and suburban areas served predominantly by overhead circuits. Choice of distribution-substation arrangement, size, and voltage rating influences system planning in two ways: toward the source via subtransmission circuits and toward the load via the primary-feeder circuits (*pp. 804–9*).

45 Mev Medical Linear Electron Accelerator. A brief description of the functions of the components of this 10-foot-long electron accelerator is given together with a discussion of its operating characteristics (*pp. 790–5*).

Student Affiliates, Affiliate Branches Reported on by Student Branches Committee. A new grade of AIEE Student membership, "Student affiliate," and a new type of branch, the "Affiliate Branch," has been formed for newly established, and as yet unaccredited 4-year engineering colleges (*pp. 826–7*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Research in Signal Corps Teletypewriter and Switching Equipments. The results of the research and development program for these equipments which provide almost all of the record communications for the U. S. Army is described in some detail. The description also includes a discussion of related research activities (*pp. 798–803*).

Protection Against Electric Shock From Central Office Communications Equipment. With the introduction of electronic facilities in central office equipment, higher voltages have been introduced; therefore, it is necessary to consider in design the protection against possible shock hazards. Various precautions taken in the design of Bell System central office communications equipment, including signaling, switching, and operation equipment, are outlined and discribed in three voltage categories (*pp. 810–3*).

Board of Directors' Meeting. This is a report of the AIEE Board of Directors meeting held during the Summer meeting, June 20, at the Thomson Club in Nahant, Mass. (*pp. 823–4*).

Three New Technical Committees Approved by the AIEE Board of Directors. A report of the scope and organization of three new Institute Committees is given. One committee lies in the realm of the Communications Division, and the other two in the Science and Electronics Division (*pp. 824–5*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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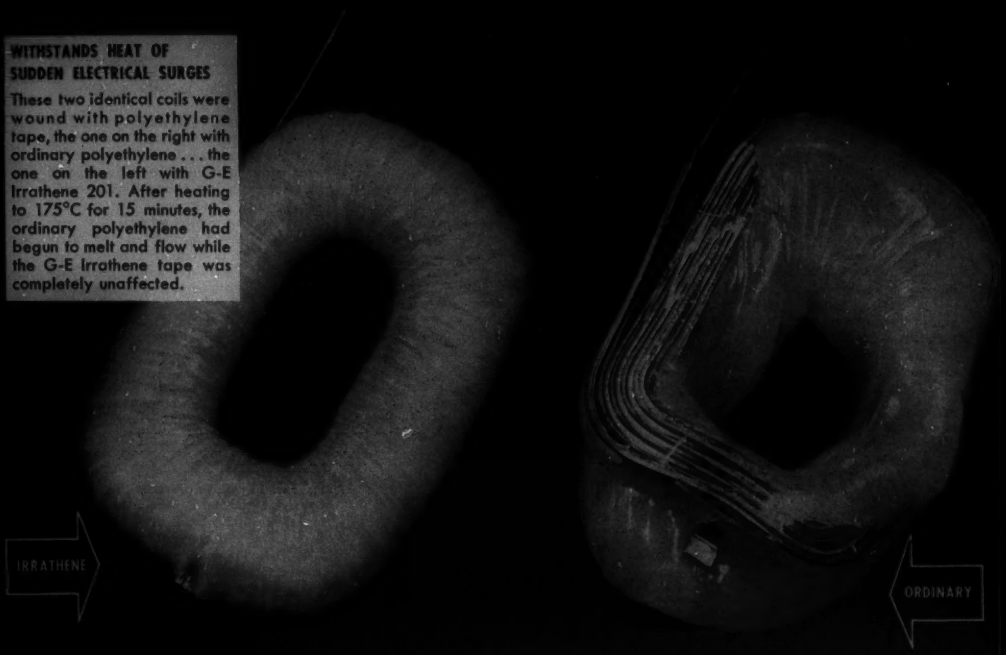
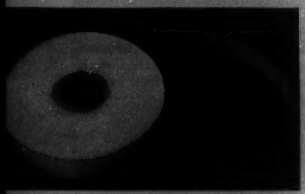
WITHSTANDS HEAT OF SUDDEN ELECTRICAL SURGES

These two identical coils were wound with polyethylene tape, the one on the right with ordinary polyethylene . . . the one on the left with G-E Irrathene 201. After heating to 175°C for 15 minutes, the ordinary polyethylene had begun to melt and flow while the G-E Irrathene tape was completely unaffected.





TAPE—G-E Irrathene tape is available in widths from ½" to 12", and in thicknesses of .002", .005" and .010".

FILM—Irrathene film is available in thicknesses of .002", .005" and .010", and in rolls 12" and 24" wide.

ENCAPSULATION—Shrinkable Irrathene 210 tape can be wound on coils or other irregular shapes then heated and shrunk to provide a tight, form-fitting, moisture-proof encapsulating layer.

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What's more, G-E Irrathene retains all the outstanding properties of regular polyethylene, including excellent dielectric characteristics . . . impervious to moisture even when directly immersed . . . chemically inert. Environmental stress cracking is eliminated. For more information, write for complete technical report and an evaluation sample of G-E Irrathene, to: Section 504-D, Chemical & Metallurgical Division, General Electric Company, Pittsfield, Massachusetts.

*Irrathene irradiated polyethylene and its manufacture is covered by patent applications of the General Electric Co.

Progress Is Our Most Important Product

GENERAL ELECTRIC

The Science of Commonplace Things

C. G. SUITS
FELLOW AIEE

The old fable, "Acres of Diamonds," teaches that one should not go abroad seeking diamonds, until one has carefully examined one's own backyard. In research, too, the moral applies. Under the scrutiny of modern science, everday phenomena have been made to yield, not only actual man-made diamonds, but "gems" of knowledge of even greater value.

Vol. 74
1955

"ACRES OF DIAMONDS" was one of the most famous popular lectures ever presented. Russell H. Conwell, pastor of the Baptist Temple in Philadelphia, Pa., and president of Temple College, wrote it about the turn of the century and subsequently presented it more than 6,000 times. Proceeds from this staggering example of oratorical endurance are said to have made it possible for thousands of young men to attend and graduate from Temple, men who would have been unable to afford college training except for "Acres of Diamonds."

This famous lecture took its title from a fable that Dr. Conwell told at its beginning. It is the story of an ancient Persian who lived near the shore of the River Indus. The Persian, it is written, "was contented because he was wealthy, and wealthy because he was contented." However, the story continues to say that,

"One day this old Persian farmer was visited by one of those ancient Wise Men of the East, who sat down by the Persian's fireside and told how this world was made. The Wise Man said the world was once a great bank of fog, and that the Almighty thrust His finger into this bank of fog, and began slowly to move His finger around, and then increased the speed of His finger until He whirled this bank of fog into a solid ball of fire; and as it went rolling through the universe, burning its way through other banks of fog, it condensed the moisture, until it fell as rain upon the heated surface of the world, and cooled the outer crust; then the internal fires, bursting the cooling crust, threw up the mountains, and the hills, and the valleys of this wonderful world of ours. 'And,' said the old Wise Man, 'if this internal mass burst forth and cooled very quickly, it became granite; if it cooled more slowly, it became copper; if it cooled less quickly, silver; less quickly still, gold; and after gold, diamonds were made. And,' said the Wise Man, 'a diamond is a congealed drop of sunlight.' "

The basic physics of this particular process for making diamonds is somewhat obscure at several points, but we must not be too critical of the Wise Man because he was thinking in broad, cosmic terms, unencumbered by trivial details, and everyone knows that clever technicians in the laboratory can take care of the details, once the broad picture has been painted. And, as a matter of fact, until quite recently *stirring fog* was as good as any other process for making diamonds; it did not work either.

The story goes on to describe how the Persian farmer, who had been up to this point quite happy, decided he wanted to be not merely wealthy but immensely rich, so he sold his farm, and went away in search of diamonds. He wandered about the world, lost the money he had, and ended up throwing himself into the sea, in despair.

Meanwhile, the man who bought his farm one day noticed a curious flash of light from the white sands of the stream running behind the house. The piece of rock he took from the stream was, his neighbors told him, a diamond. He went back to the stream and found more and more of these beautiful rocks, and he became immensely wealthy. The story concludes:

"Had the Persian farmer remained at home, and dug in his own potato patch, instead of wretchedness, starvation, poverty, and death in a strange land, he would have found Acres of Diamonds."

This is a fable and of course has a moral; in fact, it has several morals. The one that fits this theme is that in research, as well as by the farm on the Indus, a careful look at the commonplace and familiar may reveal some exciting gems of scientific knowledge. Many everyday phenomena can be made to yield a glittering array of new facts under the scrutiny of modern scientific research.

PROMISE OF SILICON

LESS THAN A DECADE AGO, the development of the first transistor by the Bell Telephone Laboratories stimulated the growing interest of scientists in semiconductors. The first transistors depended on a relatively rare element, germanium, and the detailed study of this substance opened the door to many practical applications of semiconductor devices. Scientists immediately began a systematic study of other elements that might show semiconductor properties. In the General Electric Research Laboratory we decided to put a major effort into the study of silicon.

Silicon is literally in everybody's front yard. It is the most abundant solid element in the earth's crust. The vast supply of rocks on this planet is mostly silicon tightly bound to oxygen.

The new use of silicon in semiconductors is converting this almost worthless raw material to a substance as valuable as the semirare element, germanium. Thanks to recent attainments in the preparation of extremely pure silicon, it is now apparent that this element may at some future

Essentially full text of a banquet address at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955.

C. G. Suits is vice-president and director of research, General Electric Company, Schenectady, N. Y.

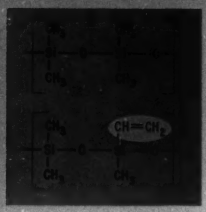


Fig. 1. Zone melting method which produces silicon with an impurity content of only one part per billion
Fig. 2. Vinyl silicone

date even outclass germanium as a useful semiconductor.

Recently silicon has been made in our laboratory with an impurity content of only one part per billion. This is achieved through the "zone melting," or recrystallization, method shown in Fig. 1. Current practices of zone melting consist of repeated recrystallizations of silicon as the ingot is slowly drawn through a gas-filled quartz tube. Induction coils are wrapped around the outside of the tube, causing the slowly moving ingot to melt in narrow zones. In this way impurities are swept to the end of the bar, leaving behind silicon which is of highest quality.

Evidence of the new level of perfection in silicon crystals is a quantity called "lifetime." This is not how long the crystal itself will last, but the length of time that an excess of electrons, purposely injected, takes to disappear. Until fairly recently, the "lifetime" of the best silicon was a ten-thousandth of a second. However, in the new crystals, "lifetime" is in excess of a thousandth of a second. This is not long by the clock, but to conduction electrons, it is practically forever. To semiconductor scientists this is one of the most exciting measurements of recent years.

This same common element, silicon, is the basis of an important new segment of the chemical industry which is rapidly coming of age—the silicone chemical industry. Probably no new material in history has been applied by engineers to so many diversified products in such a short time as these new chemicals called silicones.

Basic research on the silicones continues at an accelerated rate as new ways are found to use these wonderful rubbers, resins, and oils. Resistance to high and low temperatures is an important property of silicones, a property which was predicted by scientists who pioneered in this field of chemistry. However, in addition, many remarkable properties were discovered which were completely unpredictable and unexpected. For example, a drop of silicone added to lubricating oil prevents foaming; a drop of silicone on a bread pan or tire mold prevents sticking; while a few drops on fabric, leather, glass, or ceramics imparts remarkable water repellency. Silicone chemicals will continue to provide a succession of surprises as new members of this numerous and versatile family come to light in the laboratory.

We have found recently that under conditions of intense corona, the durability of silicone rubber is unique. For example, it will last for thousands of hours where any other natural or synthetic rubber will fail in minutes. The mechanical strength of silicone rubber grows each year as new structural secrets are discovered; until now it is in the range of the best natural and synthetic rubbers. This has been thrilling progress because the first silicone rubber we saw in the laboratory was about as strong as wet newspaper.

We have long wanted a silicone rubber with a handle, a chemical handle that would allow us to join it to other elastomer molecules. We now have a silicone with a vinyl group that serves just this purpose—as shown in white in Fig. 2—and it can be copolymerized with other synthetic and natural rubbers in any proportions.

FRACTURE PROBLEM IN METALS

FOR COMMONPLACE PHENOMENA in everyday experience, it would be difficult to find a better example than the

Fig. 3 (left). An example of fracture is shown by this crack in a ship. Fig. 4 (right). Break in a metal specimen

property of all materials of breaking under stress. Fracture in a variety of forms imposes an ultimate limitation on the performance of a vast number of structural and mechanical bulwarks of modern civilization—engines, motors, generators, turbines, trains, airplanes, bridges, buildings, machines. There are few subjects more important and basic than the study of the strength of materials, which comes to focus in the study of the phenomena of fracture.

Economics exerts a relentless pressure on the designer of mechanical things to approach ever nearer to the limit of the strength of his materials of construction, or even to exceed this limit, as in the case of World War II vessels.

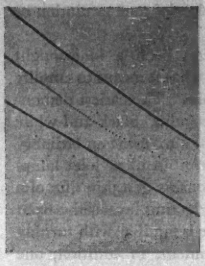
Of the 1,220 ships of this class built during 1941–44, a substantial number of them broke in two, and more than 400 developed serious cracks. See Fig. 3.

It has been customary to distinguish several different types of fracture in metals on the basis of the appearance or the conditions that caused it. We talk of cleavage, or brittle fracture, shear fracture, high-temperature rupture, and fatigue fracture. It now appears that all of these "types" have one feature in common, namely, that all are preceded by some plastic deformation resulting from slip, in which the parts of a crystal slide over each other on definite crystallographic planes. It seems likely that the slip starts from an area of crystal imperfection—the first nucleus of fracture.

Actually, until recently little has been known of the fundamental reasons why metals break. Now scientists are studying the basic phenomena in great detail and the outlines of the picture are becoming increasingly clear. Dr. J. R. Low of our laboratory recently traced the complete history of the development of fracture from its origin at an atomic level to the final failure of the metal specimen, and this study is very revealing. Here is what the final break looked like (Fig. 4). This break was preceded by a tiny but microscopically visible crack which appeared at only 10 per cent of the ultimate strength of the material. So the metal which, when perfect, fails ultimately at 50,000 pounds per square inch, say, had generated visible seeds of failure at only 5,000 pounds per square inch stress.

If we follow the tiny crack back to its atomic origins, we find a crystal dislocation, or irregularity. A group of these is shown in Fig. 5 in the microscope photograph of a region of a crystal which subsequently developed a crack. The tiny pits were formed by etching, and serve to locate irregularities of atomic dimensions in the metal crystal. The irregularities in the arrangement of a few atoms are revealed by the etch pattern; they are the ultimate cause of failure of a mechanical structure. Hence these atomic irregularities, or dislocations, have become a key of great importance, and are being studied intensively.

If we could make crystals without atomic irregularities, perfect crystals, they would be about 100 times stronger than imperfect ones. We have succeeded in doing that during the last 2 years, and now have perfect crystals of zinc, copper, molybdenum, tungsten, iron, and many other substances. Fig. 6 shows a perfect copper crystal bent elastically to a stress of 400,000 pounds per square inch. These perfect crystals of pure metal will support up to 1,000,000 pounds per square inch in tension, and are stronger than the strongest alloys, but thus far we can only make them in the form of tiny filaments. We hope they will point the way to new levels of strength in practical structural materials.



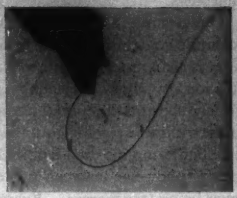


Fig. 5 (left). Microscope photograph showing crystal dislocation. Fig. 6 (right). Perfect copper crystal bent to support 400,000 pounds per square inch

SOURCES OF POWER

SUNLIGHT, uncongealed, is another familiar thing in our life, and, for years, scientists have sought a practical way of obtaining electric energy from sunlight. This is an especially intriguing target, for, like water power, the reward is free energy—"free" in the sense that there is no fuel cost. Within the past year, interesting, but still small-scale, solar power sources of substantially improved efficiency have been demonstrated. The home and industrial use of electric power from sunlight is still a long way off, but it is an intriguing area for basic research into something close at hand.

There is, of course, another power source much in the news these days; but the subject of this article is how scientists are digging into common, familiar things, and for all its tremendous importance, atomic energy still is produced by elements that cannot yet be classified as common.

Related to the studies of semiconductors and solar power are a whole group of important new scientific projects in the field of light itself. A recent dramatic development is the direct light amplifier—a phosphor surface that actually emits more light energy than strikes it, and does this proportionately so that a picture image projected on the surface

Fig. 7. Demonstration showing direct amplification of light

is brightened many times without loss of tone gradation or sharpness.

Direct amplification of light has been a long-sought scientific goal, but the basic idea of what it means to amplify light is sometimes difficult to explain. The easiest demonstration involves projecting a regular black-and-white lantern slide on the special phosphor film, using an ordinary lantern slide projector equipped with an ultraviolet lamp. The light amplification cell itself consists of a thin film of a special phosphor between two conducting layers, the front layer being transparent. Everyone is familiar with turning on a projector, but in this experiment, in addition, one "turns on the screen," and thereby obtains a great increase in brightness. Very little current is required, and small dry batteries are more than adequate.

Before the screen is turned on, the image is very dim, as shown on the left of Fig. 7. The picture is brightened not by increasing the intensity of the projector lamp or by opening up the projector lens; rather, it is done by applying a voltage to the screen itself. The brightness increases gradually as the voltage is turned up, and by the time 100 volts has been applied, the image looks like the test pattern on the right, Fig. 7.

Many who see this for the first time ask, "What is it good for?" This is, of course, a very important question, but scientists, by experience, know that predicting the future application of new basic knowledge is highly speculative. Light amplification in a single phosphor film is a fundamental scientific achievement; in this regard it is very similar to Lee de Forest's discovery of the 3-element vacuum tube amplifier in 1906, which made it possible for the first time to amplify electronic currents. At that time De Forest was not only asked, "What is it good for?" but, 7 years after the discovery, he and his associates were brought to trial for using the mails to defraud. They were accused of of selling stock "in a company whose only assets," according to the Government prosecutor, "were De Forest's patents, chiefly directed to a strange device like an incandescent lamp, which he called an 'audion,' and which device has proved to be worthless." In summing up his case, the prosecutor stated that De Forest had said, "...in many newspapers and over his signature that it would be possible to transmit the human voice across the Atlantic before many years. Based on the absurd and deliberately misleading statements of De Forest, the misguided public, Your Honor, has been persuaded to purchase stock in his company."

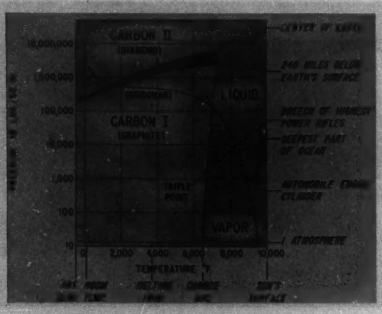


Fig. 8. Phase diagram for carbon

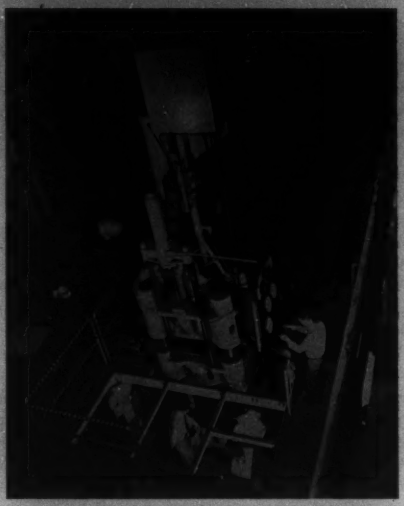


Fig. 9. Large hydraulic press used in making diamonds. Pressure vessel is the limiting factor

There may eventually be many practical applications of the light amplifier, including the so-called "picture-on-the-wall" television set, but it is no more possible to predict these with certainty now than it would have been to foresee the extent and ramifications of modern radio and television when the first audion tube was invented 50 years ago.

MAN'S ATTEMPTS AT DIAMOND MAKING

ALLEGORICALLY SPEAKING, the items which have been discussed—pure silicon, vinyl silicone, perfect crystals, solar power, light amplifiers—are all diamonds of the type the Old Wise Man from the East said we might find by digging in the right places.

Some fundamental digging in the right places also has produced some real diamonds in our laboratory. Diamond is a crystalline, transparent form of carbon, and carbon is a very common substance, so that in this case, too, research has added glamour and value to a very ordinary material.

The story of man's attempts to manufacture diamonds is one to capture the imagination. It involves famous chemists as well as charlatans, claims of success and admissions of failure, simple gadgets and striking experimental techniques; all in more than a century of confusing but fascinating history.

Many of us were taught in early science courses that diamond could be made from carbon under high heat and tremendous pressure, and many reference sources credit Moissan with accomplishing this feat in 1894. But a well-known mineralogist, writing recently for an encyclopedia,

has said, "For many years it was thought man had made small diamonds in the laboratory. When, during World War II, industrial diamonds became of strategic importance, these claims were thoroughly investigated in the hope that the natural supply from the South African mines could be augmented. All claims advanced prior to 1950 that diamonds had been made synthetically by 'artificial' methods have been demonstrated to be false, and many government and industrial research laboratories both here and abroad are still working on the problem. If it should become possible to produce in quantity a comparatively cheap form of synthetic diamond, tremendous strides could be made in the machining and working of metals and glass."

The early attempts to make diamonds are interesting enough in themselves to deserve attention. Henri Moissan dissolved sugar charcoal in molten iron and quenched the solution in cold water in order to crystallize the carbon under the great internal pressure supposedly generated by contraction as the mass cooled from the outside. Upon dissolving the metal from the solidified melt, he found traces of a hard transparent material in the residue. The famous French scientist assumed he had made diamonds. We now know that the pressures required could not be attained by this method.

Following Moissan, Sir Charles Parsons spent over 25 years of extremely diversified experiments, including the firing of a high-powered rifle into a tiny hole at the range of 6 inches. In 1920 he believed he had confirmed and extended Moissan's experiment.

In 1924 Mellor's "Comprehensive Treatise on Inorganic and Theoretical Chemistry" said that laboratory production of diamonds was well authenticated. Nevertheless, the story was not universally accepted. And Parsons himself at about that time began to entertain doubts about his own earlier identifications of what he thought were diamonds. He undertook a scrupulous re-investigation and submitted his new evidence to the editor of *Nature*. He told how he had been misled into regarding as diamond various transparent, singly refracting minerals which were very resistant to chemical reagents and would not burn. These so-called spinels have undoubtedly been the basis for many claims of success which later proved unfounded. Spinel crystals are, in fact, the "fool's gold" of diamond-making history. It was Parsons' final conviction that neither he nor anyone else had ever succeeded in making diamond in the laboratory.

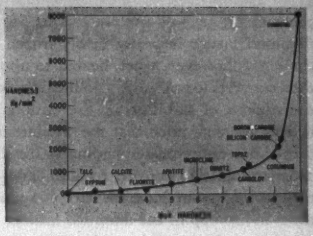


Fig. 12. Hardness of the diamond (Knoop indenter)

Another Britisher figures prominently in diamond-making history. J. B. Hannay reported in 1880 that he had made diamonds by heating a mixture of hydrocarbons, bone oil, and lithium at red heat in sealed wrought-iron tubes. Parsons said in 1920 he could not repeat Hannay's work. By 1950, Professor N. V. Sidgwick of Oxford, in his "Chemical Elements and Their Compounds," reviewed the pro's and con's of Hannay's claims and concluded that the artificial production of diamonds had never been shown to have been a success. He added that recent thermodynamic calculations which yielded the temperature and pressure requirements showed them to be so extreme that it was very improbable that any of the efforts to produce diamonds thus far could have succeeded.

DIAMONDS FROM THE LABORATORY

THESE RECENT STUDIES of thermodynamics provided our research team with the springboard they needed to undertake the diamond-making project some 4 years ago. The carbon-phase diagram of Fig. 8 will aid in understanding the problems involved, since the diamond phase of carbon is thermodynamically stable only at very high pressures. Here pressure is plotted vertically, temperature horizontally. Parts of this diagram have been established very accurately by experimental measurement, while some parts of the diagram rely entirely upon thermodynamic calculations. There is very little direct experimental basis for the boundary line between the graphite and diamond-stable regions, particularly in the high-temperature end of the curve.

The upper limits of pressure and temperature that scientists were known to have reached in controlled experiments are shown by the dotted line running across the diagram. Professor Bridgman of Harvard University is the outstanding investigator of superpressure phenomena, and the region he has studied is shown, while Basset of Paris has been the most active worker in the very-high-temperature–moderate-pressure region.

Here a limitation of the phase diagram must be pointed out. The diagram shows pressure and temperature, but not time, and in phase transitions, time is a very important quantity; unfortunately, stability calculations do not yield the time required for the phase transition to take place. As the diagram shows, graphite is the stable form of carbon at room temperatures and pressure. All natural diamond thus exists as an unstable crystal form and at ordinary

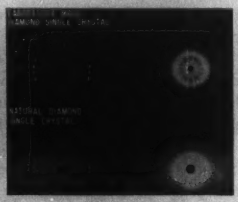


Fig. 10 (left). First man-made diamond, with diamond-tipped phonograph needle to indicate its size. Fig. 11 (right). X-ray diffraction pattern for diamond

pressure it should really revert to graphite. The diamond lattice is pretty firmly frozen in place. It will thaw out, however, when heated to about 1,700 F, and it then converts to graphite. So the phase diagram delineates the regions of stability for the various forms of carbon; it does not guarantee that the attainment of the temperature and pressure corresponding to the diamond phase will cause graphite to convert to diamond. The temperature may be too low to shake the carbon atoms loose and permit them to regroup in the diamond lattice; or too much time may be required for this to take place.

From a thermodynamic standpoint, it appeared in 1950 that there was a fair possibility of making diamonds in the region above 1,000,000 pounds per square inch and several thousand degrees F, provided these conditions could be reached, and held long enough. The job was to develop apparatus capable of operating at these levels, not just momentarily but for extended periods of time. With the attainment of a new region of high temperature and superpressure as an objective, our team of scientists began an all-out attack on the problem.

A large hydraulic press was used in this research (Fig. 9) but this size tends to be misleading. The size of the press, or the force it is capable of exerting, has very little to do with the maximum pressure that can be generated. The pressure vessel is the limiting factor.

Professor Bridgman had done considerable work on using multiple shrink bands similar to those employed in making large gun barrels. By making use of some of the known pressure methods of Bridgman, and by developing some new ways of distributing stress and giving support to critical parts, our research group succeeded in making a pressure vessel that can be operated up to at least 1,500,000 pounds per square inch. Lately, this pressure has been increased to 2,700,000 pounds per square inch. Some completely new and ingenious techniques permitted them simultaneously to achieve temperatures up to 5,000 F. Finally, they found that they could maintain these tremendous combined temperatures and pressures—equivalent to those existing some 240 miles beneath the earth's surface—for prolonged periods of time.

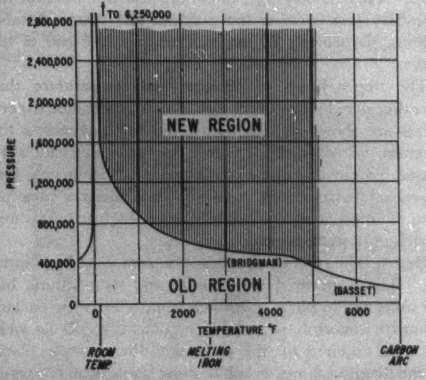


Fig. 13. Pressure-temperature plot which indicates a new region for research

Our first man-made diamond is shown in Fig. 10, with a diamond-tipped phonograph needle present to give an idea of its size. It is about 1/16 inch long. Most of the thousands we have now produced are even smaller, but all are well within the size range needed for the bulk of industrial uses in cutting, grinding, and polishing. Some are clear white; others have the wide variety of colors found in the diamonds dug from the earth. They are, in fact, identical to natural diamonds. They are not "imitation" diamonds or "diamond-like"; they are purely and simply diamonds. All of the variations in color, crystallinity, and clarity found in natural diamonds are observed in the laboratory product.

The X-ray diffraction pattern provides a simple "fingerprint" for diamond, as shown in Fig. 11. The internal arrangement of the carbon atoms in the diamond crystal, not the external appearance of the crystal, produces the characteristic X-ray diffraction pattern. At the top is the pattern for a man-made diamond and beneath is the pattern for a natural diamond. The process by which these diamonds have been made has by now been repeated hundreds of times with successful results.

The fascination and beauty of diamond gem stones sometimes obscures the real importance of this unique substance. Diamond is, by a wide margin, the hardest substance known, as shown by the curve of Fig. 12 which gives the actual indentation hardness plotted against the mineral hardness number. Therein lies a tremendous potential for manufacturing industries. Cutting and grinding operations are basic to a large segment of industrial manufacture, and the speed and efficiency of these operations is a multiplier which exerts great leverage on the American economy. This becomes increasingly true as industrial technology produces ever stronger and harder materials in support of the inexorable competitive demand for higher temperature, higher speed, higher stress, and higher mechanical performance.

In addition, diamond is a strategic material of great importance. We presently depend entirely upon the supply from Africa, which produces 98 per cent of all of the world's diamonds. From this source there is not enough naturally occurring diamond to permit widespread use in industry, and this scarcity supports the present price of $7,000 per pound for the lowest industrial grades. For industrial cutting stones, the price runs up to $1,000,000 a pound.

Although photographs of man-made diamonds have considerable beauty of their own, to the scientist the most beautiful picture to come out of our diamond research project is the simple graph of Fig. 13.

It will be obvious that substances other than carbon can be subjected to these never-before-attained pressures and that pressure-temperature-time cycles never before available now lie before us. We have available a large new and exciting scientific frontier. Acres of diamonds could hardly have a more thrilling interpretation. From these new acres we may be able to extract scientific gems of even greater value than diamonds.

1954 Employment Questionnaire—II

COMPARISON OF ANSWERS BY SUPERVISORS AND NONSUPERVISORS

L. F. HICKERNELL
CHAIRMAN, PLANNING AND CO-ORDINATION COMMITTEE

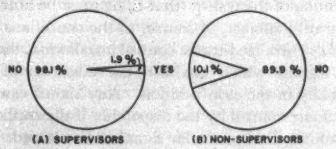
PUBLICATION of the first report in *Electrical Engineering*, February 1955, pp. 96–7, disclosed that in reply to Question 3 on Employment Status, those who answered classified themselves as follows:

3.4 per cent Self-employed	52.6 per cent Supervisor
3.5 per cent Employer	40.5 per cent Nonsupervisor

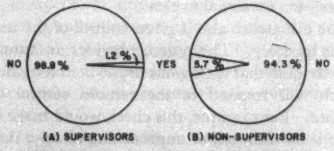
Several members and officers have expressed an interest in a comparison of the answers by supervisors and nonsupervisors. Accordingly, your committee has conducted a cross-analysis between Questions 3 and 7 to 11, as shown in the accompanying diagrams.

Within each of the four shadings of opinion, the widest divergence occurs in the categories (Q9, 10) collective bargaining "definitely is needed" and (Q11) "definitely agree" that the responsibility and judgment required of an engineer are incompatible with unionization, as shown below:

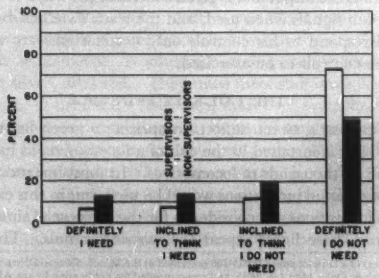
Question and Category	*Supervisors, Per Cent*	*Nonsupervisors, Per Cent*
Q9. As employee, need for collective bargaining: Definitely I need	7	13
Q10. Regardless of employment status, need for collective bargaining: Definitely needed	10	15
Q11. Engineer's responsibility and judgment incompatible with unionization: Definitely agree	59	42



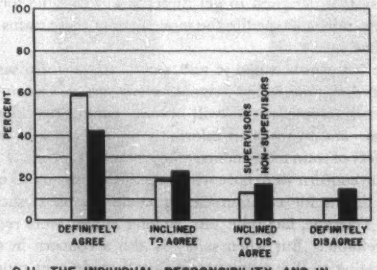
Q 7. MEMBER OF UNION.



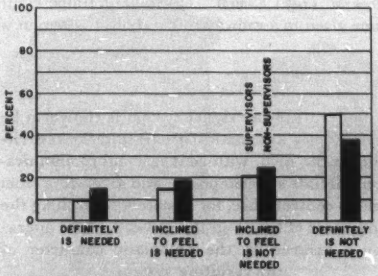
Q 8. NOT A UNION MEMBER, BUT REPRESENTED BY UNION.



Q 9. AS AN EMPLOYEE, NEED FOR COLLECTIVE BARGAINING.



Q 11. THE INDIVIDUAL RESPONSIBILITY AND INDEPENDENT JUDGMENT REQUIRED OF AN ENGINEER ARE INCOMPATIBLE WITH UNIONIZATION.



Q 10. REGARDLESS OF EMPLOYMENT STATUS, NEED FOR COLLECTIVE BARGAINING.

RAILWAY SIGNALING

G. W. BAUGHMAN
MEMBER AIEE

MANY NEW AND USEFUL TECHNIQUES have become available in the communications field in recent years. There is a natural and quite proper desire to employ these new techniques for the control of railway traffic. A modern railway signaling system must have as its foundation properly designed fail-safe circuits; but under the careful guidance of a signal engineer, the more conventional communications circuits may then be superimposed and the remote control of railway traffic achieved with complete safety.

RAILWAY SIGNALING AS A COMMUNICATIONS SYSTEM

COMMUNICATIONS ENGINEERING may be defined as "that branch of engineering which concerns itself with methods for communicating by electric instruments." Railway signaling, as known today, belongs to this branch of engineering. The primary purpose of railway signaling is to expedite railway traffic, but obviously this must be accomplished with safety.

A railway signaling system may be looked upon as a complete system designed to get directives in suitable form to moving trains to expedite the movement of these trains with complete safety.

The two words expedite and safety are never disassociated in designing railway signaling systems. The complete modern signaling system will always include two kinds of circuits—one to transmit information; the other to insure the safety of train movements.

If the concern were only with expediting, any or all of the usual means for communicating could be used, such as voice, Teletype, facsimile, etc., so long as they were reasonably reliable. But when safety is also a concern in communicating to the moving train, another element must be added. This element in the communications system can be called the "fail-safe principle."

Centralized Traffic Control. Centralized traffic control is the name given to a railway traffic control system in which the dispatcher, located at a central point, directs the movement of trains over his territory by the remote control of the wayside signals. The locomotives hauling these trains in some cases are equipped with cab signals which repeat for the engineman in his cab the indications of the wayside signals. In effect, the dispatcher then controls the miniature signals in the locomotive cabs.

As stated, the remote control of railway traffic has two aspects. One aspect is that safety must be assured. Safety is assured by the application of standard railway signaling principles and practices for detecting automatically the presence of a train on the rails, and setting up automatically, in the field, the protection for that train. In addition to the safe spacing of trains, this automatic protection includes the detection of broken rails, the misalignment of track switches, the opening of a draw-bridge, etc.

The other aspect is that the dispatcher must be able to organize and carry out a program for the expeditious operation of the trains; that is, he must be able to expedite the traffic, subject, of course, to the conditions of safety.

In a centralized traffic control installation, the main wayside signals which establish the direction of traffic are normally in the stop position. Any signal can be cleared by remote control by the dispatcher if the traffic conditions are safe for this particular signal to be cleared. Before this signal will respond to the control of the dispatcher, however, a check is made automatically in the field to determine that it is safe for the signal to clear.

The dispatcher also is given control of the track switches in his territory. The system provides an automatic check to determine that conditions in the field are safe before any switch will respond to the remote control by the dispatcher. For example, this check would make certain that there is no train on, or approaching closely, the switch the dispatcher wished to throw.

Thus the dispatcher is given control of the wayside signals, the cab signals when used, and the track switches, but they will respond to his controls only if conditions are safe for these controls to be exercised.

A modern railway signal system is shown to be founded on automatic fail-safe interlocked circuits in the field, with conventional communications circuits superimposed, and extending from field to control office, for remotely controlling the movement of trains on the railway. Safe operation is assured by the automatic character of the resulting system.

THE FAIL-SAFE PRINCIPLE

SUPPOSE A SMALL SIGNAL comprising a green light and a red light is installed in the cab of a locomotive, as has been done on thousands of locomotives. In most instances three or four signal indications would be used, but in this example two indications are considered for the purpose of simplification. These lights repeat the wayside signals. They are

Full text of a District paper DP55-300 presented at the Middle Eastern District Meeting, Columbus, Ohio, May 4–6, 1955, and recommended for publication by the AIEE Committee on Land Transportation.

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automatically controlled in such a manner that when it is safe to proceed at high speed this fact will be communicated to the engineman by the display of a green light in his cab. Should conditions in advance of the moving locomotive change—such as the overtaking of a slower moving train, or the approach to a slow-speed turnout, or to an open drawbridge—the system must automatically, and promptly, communicate that fact to the oncoming locomotive, and the green light must change to a red one.

But suppose the system at this particular juncture should be unusable because of an open line wire, or a bad contact, or a failure of power. It would be disastrous if the automatic controls could not get through to change that green cab signal light to a red cab signal light in time for the engineman to observe the change, reduce his speed, or bring his train to a stop.

The potential disaster in this situation is avoided by incorporating the fail-safe principle. The control circuits are normally energized; the green light is displayed only as long as the circuits involved are intact, signaling current is flowing, and all contacts are functioning normally. A failure in the circuit at any of these points immediately and automatically extinguishes the green light, irrespective of any other conditions, and causes the red light to be displayed. The circuit in control of the cab signal has been designed on the closed-circuit principle, as it is spoken of in the railway signaling field, or on the fail-safe principle—as said elsewhere.

Frequently this type of circuit is referred to as a "vital" circuit. The control is, of course, fully automatic.

In a fail-safe signaling or a vital circuit, the more restricting, or the red indication, always is obtained by removing electric energy from the circuit; that is, by interrupting in some manner the flow of current in that circuit. The nonrestricting, or green indication, is obtained only when electric energy flows in the control circuit and through the coils of the electric instruments in that circuit.

If the display of a clear, or green, indication is the normal condition, as is usually the case, it is said that the control circuit is a normally energized circuit. The restricting, or red indication, then results whenever the flow of electric energy is discontinued from any cause in the normally energized control circuit.

Now it is not sufficient to design only the circuits on the fail-safe principle. The electric instruments referred to in this definition also must be designed on fail-safe principles.

For example, the electric instruments in the vital circuit employ gravity bias to operate them when the energizing current is removed. Nonfusing contacts, such as graphite against silver, are used. They must meet standards of performance, of insulation resistance, flash-over voltages, etc., that are entirely unnecessary in the usual communications circuit. Such instruments, relays, etc., are called vital instruments; examples will be shown later.

Now, it is inherent in the fail-safe circuits just described, that the vital operations are automatic. A restricting directive is obtained automatically when a wire breaks and interrupts the circuit, or a source of power fails.

It will be apparent that fail-safe circuits can be interlocked, or automatically sequenced. And of most impor-

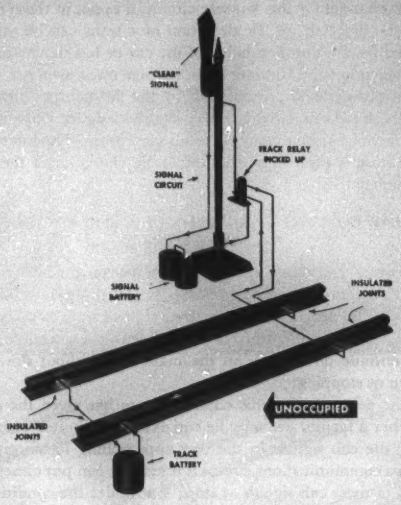

Fig. 1. Current flows through rails of entire section from battery to relay

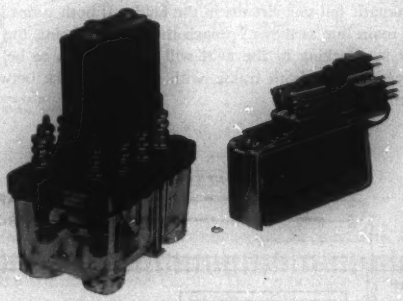

Fig. 2. Typical relay used in vital circuits; typical relay used in nonvital circuits

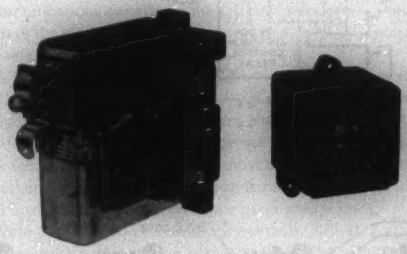

Fig. 3. Track relay of latest design; nonvital relay of latest design

tance, by employing the running rails as the communications channel for this fail-safe circuit, a break in these rails can be detected, or the detection of a train can be established by the shunting effect of the car or locomotive axles rolling upon the running rails. Open track switches and open drawbridges are detected by the fail-safe rail circuit. So these fail-safe circuits with properly designed electric instruments can be employed to do vital jobs. The safety of operation is assured by the automatic character of the resulting system.

WHERE CONVENTIONAL COMMUNICATIONS CIRCUITS ARE USED

ASSUME THAT TWO HIGH-SPEED TRAINS on a single track line are approaching a meeting point from opposite directions. The dispatcher wishes to direct one train to take the siding and give the other train preference by permitting it to continue on its way on the main line without slowing down or stopping.

The centralized traffic control system has given the dispatcher a facility whereby he can exercise a limited control over the cab signals in the two approaching locomotives. If this communications circuit is intact, he can put either or both of these cab signals at stop; but under the conditions of the two trains approaching each other, he can clear only one or the other of them at a time, and then only when conditions in the field are safe. In other words, his remote control of the cab signals is subject to the interlocking of the automatic fail-safe circuits in the field. If both trains hold the main line as they approach the meeting point, the circuit interlocking in the field will cause signals to be displayed to stop both trains, with a safe distance between them.

Obviously, this is a situation in which the dispatcher can safely exercise a choice. He can decide which train to give preference. He knows that if his communications system fails at that particular moment, the worst that could happen would be that both trains would be stopped on the main line with a safe distance between them. There would be delays, but no accident. So he uses his communications system, which in this instance transmits the message by code, to operate a track switch which will divert one train to the siding track. He then will display a wayside signal for the train which is to take the siding. The wayside signal will say to the inferior train: "Take the siding and wait for an approaching train to pass you on the main track." The cab signal will repeat the message in the cab.

Both trains could be stopped with a safe distance between them. But the train movements can be expedited by arranging the meet so as to delay only the inferior train, and this is done by employing a nonvital type of communications circuit. Safety is assured by the automatic fail-safe circuits in the field. These vital circuits, on the ground are interlocked, and prevent any unsafe display of signals or unsafe movement of a switch even should the nonvital remote control communications circuits become deranged or inoperative.

THE TRACK CIRCUIT

THE UNDERLYING FAIL-SAFE CIRCUIT in all modern railway signaling is the track circuit. The track circuit detects and registers the presence on the rails of a railway vehicle or train. It detects, as well, a broken rail, an open switch, or an open drawbridge. The track circuit is the foundation of all modern railway signaling.

The track circuit, shown in Fig. 1, comprises a source of

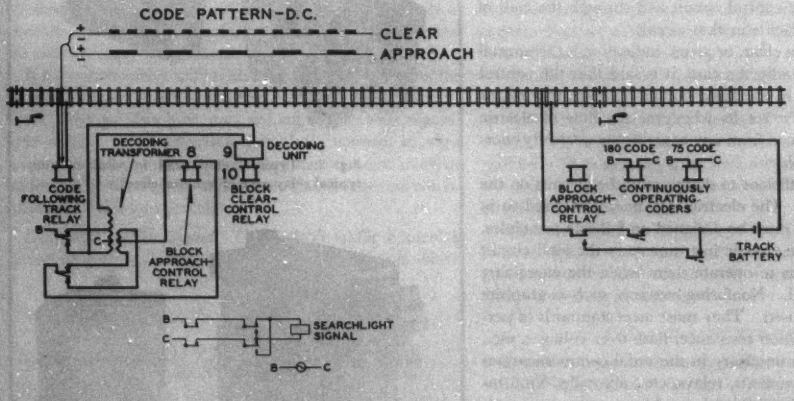

Fig. 4. Coded track circuit can be expanded to communicate more than "stop" or "go" to the oncoming train

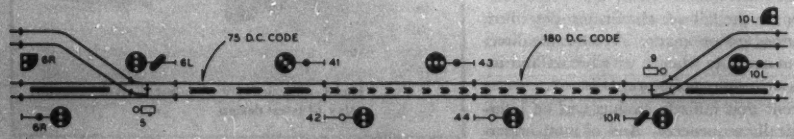

Fig. 5. Wayside signal system

Fig. 6. CTC control cabinets

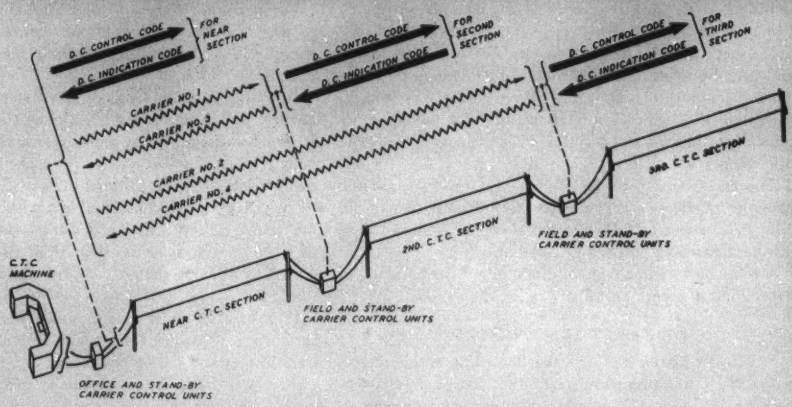

Fig. 7. Diagram showing CTC sections

d-c or a-c electric energy—such as a track battery, a low-voltage rectifier, or a transformer, the running rails, and a relay. The armature of this relay is biased by gravity to open a contact when energy is removed from the relay winding. The track circuit may be a mile or longer and is isolated from adjacent track circuits by insulating rail joints.

The wayside signal governing the entrance to this mile or more of railroad is shown, for purposes of illustration, as an electrically operated semaphore mechanism. The semaphore blade is biased to the stop position by gravity. An attempt has been made to show this equipment consistently with the time when the first track circuit was used—1872.

When a car occupies the track circuit, the track circuit current is shunted away from the coils of the track relay by electric contact between the track rails and the wheels of the vehicle.

When deprived of energy, the armature of the track relay drops, under the pull of gravity, and opens the local circuit to the semaphore holding mechanism. The semaphore blade goes to the stop position under the pull of gravity when its holding circuit is opened by the contact on the track relay.

Notice that a break in the track rails, an open wire, or a battery failure will bring about the display of the stop signal at the entrance of the block. The elementary system as shown is capable of saying STOP or GO to an oncoming train.

The Fail-Safe Principle in Railway Signaling Instruments. As mentioned earlier, it was not sufficient to design only the communications circuits on the fail-safe principle. The designs of the electric instruments must also be based upon the fail-safe principle.

A track relay is shown in Fig. 2 which might be installed in the circuits shown in Fig. 1, and beside it is a typical relay found in nonvital circuits. Note the electric clearances between terminal posts for the vital relay. Electric leakage and voltage breakdown must be such that lightning or other high-voltage surges do not damage the top plate and lower its insulation resistance to an unsafe level.

Note the silver to carbon block contacts. Silver and carbon constitute a nonfusing combination. The armature of this relay cannot be held in its energized position by the fusing of contacts by lightning or by high current from any source. Note also that the armature and contact assembly

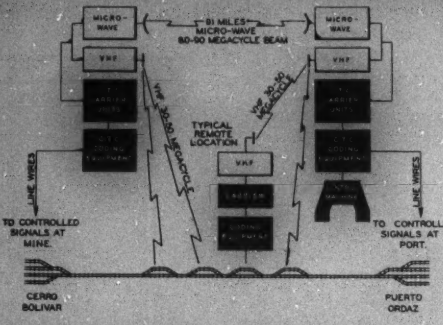

Fig. 8. Four remote-controlled passing tracks with CTC system used by the Orinoco Mining Company, Venezuela

is biased to the de-energized position by gravity, not by spring forces.

Magnetic air gaps in this relay are carefully determined, and fixed by doweling, and by nonmagnetic safety stop pins. Then by employing a nonaging silicon steel, the ratio of release to pickup, which is a final measure of the safety of the relay, is established and maintained over the long life of the instrument.

The relays shown in Fig. 2 were selected because the structure of the two instruments showed most clearly the difference between vital and nonvital types. Neither was of the latest type used in railway signaling.

A relay of the vital type, and one of the nonvital type, both of latest design, are shown in Fig. 3.

THE CODED TRACK CIRCUIT

IT WILL BE NOTED IN FIG. 4 that the track circuit energy is now coded at a predetermined rate. The track relay follows the ON and OFF intervals of the code. Contacts on this relay pole change energy to the primary of the decoding transformer. So long as the track relay is responding to the track circuit code, a code-detecting relay is energized through this transformer by mechanical rectification. This is the basic coded track circuit.

The coded track circuit has all of the fail-safe attributes of the steady energy track circuit. In addition, it is capable of transmitting more information than just STOP and GO.

It will be seen that coding instruments have been provided for generating two code frequencies: namely, 180 cycles per minute and 75 cycles per minute. At the entering end of the block, decoding unit *9*, an electric filter, is so designed that it passes electric energy only at the higher frequency of 180 cycles per minute, or 3 cycles per second. It follows that relay *10* will be energized only when the track circuit energy is coded at the 180-cycles-per-minute rate. Relay *8*, however, will be energized at the 75-cycle-per-minute code rate, as well as at the 180-cycle rate.

The two relays, *8* and *10*, obviously can be employed to say STOP when both are de-energized, GO SLOW when relay *8* only is energized, and GO FAST when relays *8* and *10* both are energized.

Additional code rates may be employed to communicate additional information to the oncoming train, without departing from the fail-safe principle.

THE WAYSIDE SIGNAL SYSTEM

THE FAIL-SAFE CODED TRACK CIRCUIT, capable of communicating to the moving train the three messages: GO FAST, GO SLOW, and STOP, apply a sequence of such track circuits to the single track between two passing sidings. See Fig. 5.

Note that the single track between the two passing sidings is divided into four track circuits, or blocks. A wayside signal controlled by its respective track circuit governs the entrance to each of these blocks.

Note that signals *10L* and *43* tell the engineman on a westbound train he may GO FAST. This message is the effect produced by the 180 coded energy in the track circuits controlling these signals.

Signal *41* conveys the message GO SLOW because the westbound train is to stop at signal *6L* at the entrance to the passing track at the left of the diagram. Track circuit energy coded at the 75 rate flows in the track circuit controlling signal *41*.

All of the eastbound signals are at stop because, for each of these signals, no coded track circuit energy is received. It will be observed that everything is cleared for a westbound move, but everything is blocked for a conflicting eastbound move. An eastbound move can be set up merely by reversing the direction of all of the track circuits between the passing sidings. Then coded track circuit energy will be received at each of the eastbound signals instead of at each of the westbound signals. All of the westbound signals would then go to STOP.

It now will be understood that all of the four track circuits between the passing sidings are reversible; that is, the transmitting and coding equipment at one end, and the receiving and decoding equipment at the other end of each track circuit can be interchanged.

The westbound signals will clear when the track circuits are pointed toward the westbound signals; the eastbound signals will clear when the track circuits are pointed toward the eastbound signals. In other words, the direction of traffic may be controlled by the direction of the track circuits between the passing sidings.

Since the track circuits cannot point both ways at the same time, it is inherently an interlocked fail-safe signal system for a single track railroad.

It will be observed that all of the safey inherent in the single track signal system resides in the interlocked fail-safe track circuits on the ground, and that the protection obtained is automatic. Direction of traffic, however, may be established simply by pointing the track circuits. Obviously, this pointing of the track circuits can be initiated over ordinary communications facilities of the nonvital type.

It should be stated at this time that by interlocking in the field, not shown, the vital circuits are so arranged that the track circuits cannot be reversed, and the direction of traffic changed, unless the single track between passing sidings is free of trains. Obviously, the dispatcher must not be permitted to reverse the traffic until a previous move has

been completed. This is another automatic check provided by the vital circuits in the field.

CTC, The Central Office Machine. It has been shown how the safety of train operation is assured by interlocked fail-safe communication circuits on the ground and that the direction of traffic over a stretch of single track can be established simply by pointing the track circuits in the appropriate direction, and that this can be done safely by remote control. Now examine the central office machine where the dispatcher exercises this control of railway traffic. See Fig. 6. This machine controls about 250 miles of single track on the Seaboard Air Line Railroad between Savannah, Ga., and Hamlet, N. C.

Note the line diagram near the top of the machine. This diagram pictures the railroad which the dispatcher controls. Every signal, switch, passing siding, or turnout appears on this diagram. When a train moves over the railroad, its progress is continuously displayed on this diagram by small lights that become illuminated as sections of track become progressively occupied.

As the track switches repond to the dispatcher's controls, or traffic direction changes and signals clear, this response in the field is indicated back on the machine by suitable lights. The dispatcher is thereby continuously informed of traffic conditions in the field. He can plan meets, keep trains moving even when meets have to be changed because of unexpected delays to one or more of the trains.

Immediately in front of the dispatcher, but not shown very clearly, is an automatic train graph which provides an ink record of all train movements in his territory. This graph advances at the rate of 3 inches per hour. At the end of each 24-hour period, the graph is torn off and filed in the same manner as the usual "train sheet."

Now the central office machine for a CTC installation may be located anywhere, either on or off the territory to be controlled. It will be obvious to the communications engineer that if there is a reliable communications channel from the dispatcher's machine to the controlled territory, the dispatcher will be able to exercise complete control over the train operations in his territory.

The reliable communications channel just called for may be a 2-wire physical circuit, a carrier channel, radio, very high frequency, or microwave. Distance need not be a factor, except in the detailed design of the installation.

Centralized Traffic Control Line Circuits. Note that the diagram, Fig. 7, shows three CTC sections. A section is merely a convenient subdivision of the railroad—from 50 to 75 miles in length—which in general contains a specified number of passing sidings, signals, switches, and other operable units.

A single pair of line wires extends from the machine to the end of the controlled territory. The switches and signals in the first section, designated the "Near CTC Section," are remotely operated by coded d-c pulses constituting a code capable of selectively operating all of the switches and signals in that section.

The switches and signals in the second CTC section are also remotely operated by coded d-c pulses, but these d-c pulses are produced by coding equipment located at the near end of the second section and operated by carrier over the same line wires extending from the machine to the near end of this section. Obviously there must be conversion equipment at the near end of the second section for converting the coded carrier pulses into coded d-c pulses for control of the switches and signals in the second section.

Similarly, the switches and signals in the third CTC section are remotely operated by coded d-c pulses produced by coding equipment located at the near end of the third section and operated by a second carrier over the same line wires extending from the machine to the near end of this section.

The return indications which keep the dispatcher informed on the response of the field equipment, and also the progress of the trains over his territory, are brought into the office over d-c and carrier channels in a manner similar to that followed in the outgoing controls.

VHF and Microwave Systems and Centralized Traffic Control. The communications engineer will now recognize that there are no technical reasons why radio or microwave cannot be employed remotely to control the fail-safe signal circuits in the field. A recently completed installation of CTC on an iron ore railroad of the Orinoco Mining Company, in Venezuela, will be of interest. See Fig. 8.

The Orinoco Mining Company's iron ore deposits are in the mountains at Cerro Bolivar, Venezuela, about 91 miles from the deep water port of Puerto Ordaz. A single-track railroad with four passing sidings joins the mine and the port. The CTC control machine is located at Puerto Ordaz.

It is worthy of note that a broad-band radio beam in the range of 80 to 90 mc bridges the 91 miles from the port to the mine. It happens that one of the towers is located on a mountain peak, and line-of-sight is obtained for the 91 miles.

The switch and signal equipment at the four sidings is very high frequency; the two nearest the port are reached by the vhf station located near Puerto Ordaz, and the two nearest Cerro Bolivar are reached by very high frequency from the station located on the mountain near the mine.

It will be understood that the coded pulses are generated by coding equipment at the office, and the control codes are directed to the desired units on the railroad by the push buttons and small hand-operated switches on the panel of the control machine at Puerto Ordaz.

It also will be understood that the vital circuits in the field are of the general type previously described, with complete safety assured by the interlocked fail-safe character of these circuits, so that no hazard can be created by failure or misinterpretation of the control codes sent out by the office at Puerto Ordaz.

The Orinoco installation is a good example of the original premise, namely: A modern railway signal system has as its foundation automatic fail-safe interlocked circuits in the field, with conventional communications circuits superimposed thereon, and extending from field to control office, for remotely controlling the movement of trains on the railway.

MAGNETIC ELEMENTS in Arithmetic and Control Circuits

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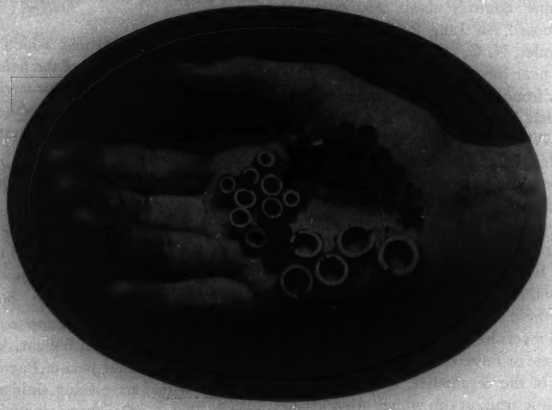

The characteristics of square-loop ferromagnetic cores and the basic circuits from which logical elements can be formed are described briefly and several typical applications are discussed. Future applications are expected to expand beyond electronic computers to include the fields of industrial control and communication.

THE INTRODUCTION of a relatively new circuit element—the square-loop ferromagnetic core or BIMAG—has made possible a sizeable reduction in the size, weight, and power, with a great increase in reliability of many parts of information-processing systems. In their earliest applications these cores were only used in simple shift registers or as memory elements. However, recent disclosures have shown that practically every logical function can be performed using cores, and complete data-processing systems have been built using them as the prime component. The characteristics of cores and the basic circuits from which logical elements can be formed will be briefly described and some typical applications discussed.

CORE CHARACTERISTICS

CORES HAVE BEEN DEVELOPED IN TWO BASIC FORMS: the first, microthin metallic tape, and the second, molded ferrites. The tape-type core usually consists of a number of wraps of very thin metal tape wound on a ceramic bobbin, spot welded in place and heat treated in dry hydrogen atmosphere. The metal tape varies in thickness from 1 mil (0.001 inch) to 1/8 mil. The tape-type cores may be fabricated in other ways and packaged in plastic bobbins. The majority of users prefer the more rugged ceramic bobbin because the metal is heat treated in its final physical position and is subjected to less strain in handling, thereby yielding better magnetic characteristics. Ferrites are fabricated in a manner very similar to that used to manufacture ceramics. In fact, the ferrite material is of ceramic origin. After the base material has been ball-milled into a fine powder, it is pressed into small toroidal shapes with the necessary binder material added and then fired in a reducing atmosphere.

A variety of metallic ribbon and ferrite cores are shown in the title picture. These cores vary in size from approximately 1/2-inch diameter to the tiny ferrites which are 90 mils in diameter. The larger cores have been used in manipulative-type circuitry where numerous turns of copper wire may be added to each core winding, while the tiny ferrite cores have been used primarily for magnetic memories where only a very few copper wires pass through the toroid itself.

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The most common method for describing the characteristics of magnetic materials is the *B-H* or hysteresis loop. The vast majority of magnetic materials used by industry have S-shaped hysteresis loops as shown in Fig. 1*A*. The unique characteristic of the core-type magnetic material is that it has a rectangular-shaped hysteresis loop, shown in Fig. 1*B*, and that the coercive force (H_c) is a small fraction of that of transformer-type magnetic materials. The rectangularity, the low coercive force, and the high-speed switching are the characteristics that have enabled these magnetic materials to be used in electronic information-processing systems with considerable success. The squareness, or B_r/B_m ratio, enables the core to store information, because the residual magnetization (B_r) is very nearly that of the maximum magnetization, or B_m. Briefly, the usefulness of the cores results from the fact that once the material is magnetized in the positive sense (which is denoted here as the binary ONE) and the magnetization is removed, the reapplication of magnetization in the same direction causes very little flux change and hence very little voltage in the windings around the core. Hence it is possible to distinguish between the two states of magnetization by interrogating and inspecting the flux change. If a core is interrogated with a negative magnetization signal (tending to switch the core to the ZERO state) and it was originally in state ONE, a larger flux change would result; if it were in state ZERO, a very small flux change would result.

The switching time of these components, or time required to change the state of magnetization, is inversely proportional to the difference between the magnetization force and the coercive force $1/(H_m - H_c)$. This means in general that the greater the magnetization force, the shorter the switching time, or the more rapidly the core will change state.

The B_r/B_m ratio for generally available cores ranges between 0.85 and 0.95, depending on the core material. The switching time for these cores varies from about 12 microseconds to less than 1 microsecond.

The core is rather unique in the field of electronic components in that it is bistable. That is, it has two discrete stable states when operated over a unique *B-H* loop. There are very few components that exhibit such a bistable characteristic. Some of the other discrete or bistable devices are gas-discharge tubes and relays. The gas tube either conducts fully or not at all; the relay contacts are either open or closed; the core is in either state ONE or state ZERO. The vacuum tube, transistor, germanium diode, and other electronic components are proportional devices, and, in fact, the great development of these components has been to make them more linear rather than less linear (as demanded by the communications industry). This unique bistable characteristic of the core, its extreme reliability, its very fast response time, and its zero quiescent-power-dissipating characteristic have made it particularly valuable for use in discrete information-processing systems.

BASIC CIRCUITS

THE CHARACTERISTICS OF THE COMPONENT have been discussed without particular reference to circuits or applications. It is well now to examine a few typical circuits of the core and then discuss their applications to specific uses in information-processing systems.

The single-diode transfer loop shown in Fig. 2 is a variation of the circuit first introduced by Professor Howard Aiken of the Harvard Computation Laboratory. The magnetic cores denoted by circles are coupled together by the diode transfer loop. The drive or advance currents are denoted by T_1 and T_2. The input to the first core may be from a similar circuit or it may be a driver current. The output from the second core may be coupled to additional cores or instead it may be utilized to trigger a driver.

The symbolic drawing shown below the schematic is a simplified notation that enables a more rapid and easily understood method of describing magnetic circuits. Each of the circles corresponds to a magnetic core. The arrows into the circles correspond to the input or drive signals, while the lines leaving the circles correspond to the output signals. The numerals within the circles correspond to the state *to* which the core is switched by the drive signal and *to* which the cores must be switched to derive an output signal. A signal on the input line will switch the core to the state designated by the numeral. A signal will appear on the output line if the core is switched to the state designated by the numeral. For example, if a bit of data, say a ZERO, were stored in the first core and the T_1 signal applied which always drives the core to state ZERO, no output would occur since no change in state resulted. If, on the other hand, a ONE had been inserted in this core and the T_1 signal applied, the core would switch from ONE to ZERO and an output signal would result across N_1. The signal is of sufficient magnitude to switch the core coupled to it by the diode and winding N_2. It is seen that when information was read into the first core at T_2, the voltage across N_1 could not cause current to flow in the transfer loop since it appears in the inverse direction across the diode.

A disadvantage of the single-diode loop which limits its application in logical circuits is the fact that transfer of information between cores is unconditional, i.e., if a core contains a ONE and an advance current is applied, all single-diode loops connected to ZERO outputs of the core will be affected. In order to perform many logical opera-

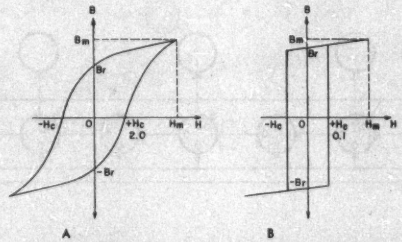


Fig. 1. Hysteresis loops: A—S-shaped type found in the majority of industrial magnetic materials; B—Rectangular-shaped type

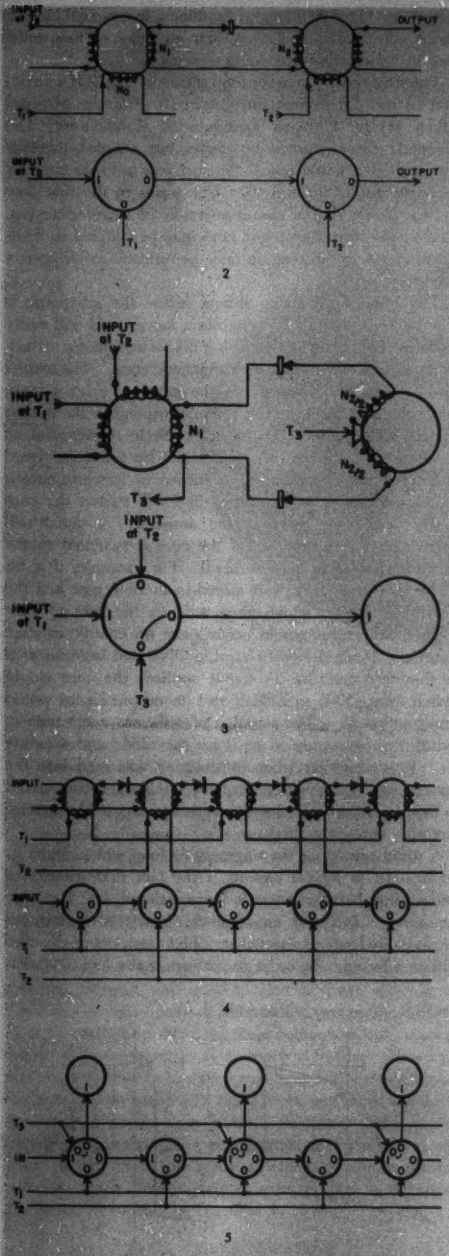


Fig. 2. Single-diode transfer loop. Fig. 3. Split-winding transfer loop. Fig. 4. Magnetic shift register (single-diode loop). Fig. 5. Magnetic register (serial in–parallel out)

tions, a conditional-transfer loop is desired; a circuit which will permit transfer of information between cores only at desired times. With such a circuit, cores can have several associated transfer loops with no interaction between them.

One form of a circuit which provides conditional transfer is illustrated in Fig. 3. It is called the split-winding or biased-diode transfer loop and is symbolically denoted by an eyebrow connecting two zeroes in the core circle. The loop consists of an output winding N_1 on the drive core, two diodes, and a receiving winding N_2 which is split into two equal parts. The advance pulse T_3 enters the circuit at the center of the split winding and leaves at one end of N_1.

It is seen that when a ONE is read into the first core at T_1 or if it should be switched to ZERO at T_2, current flow in the split-winding loop is inhibited by the back impedance of at least one of the diodes. When T_3 is applied, no net magnetizing force is supplied to the second core since the current will divide equally through the two halves of the split winding. The current through N_1 will cause the first core to switch to the ZERO state, inducing a voltage across N_1 in such a direction as to reduce the current through this winding; thus increasing the current through the bottom half of the loop. This circuit can be designed so that the resultant unbalance in current through the upper and lower halves of N_2 will be sufficient to cause the second core to switch to the ONE state.

It should not be construed that the two circuits just described are the only ones available using cores. On the contrary, the transfer circuits can be replaced by inductive-capacitive delay lines, transistors, diode amplifiers, and, in some cases, vacuum tubes. Reliable design techniques have been developed and a great deal of operating experience obtained for the two circuits just described, hence they are used here as examples of what can be accomplished with cores. With these circuits all of the basic building blocks for arithmetic and control circuits can be formed. Some of these will be described briefly.

LOGICAL ELEMENTS

A magnetic shift register is illustrated symbolically in Fig. 4. The cores are coupled together by single-diode transfer loops. The odd and even cores are each laced with an advance winding and these are alternately pulsed. The data or information are stepped or shifted through the register by transferring the contents of the odd cores to the even cores by exciting advance winding T_1, and then from the even cores to the odd cores by exciting advance winding T_2. The application of the conditional-transfer loop to the shift register to provide a parallel read-out and storage is shown in Fig. 5. In this case when the odd cores are interrogated by T_3, the data are transferred to the cores shown above the shift register. Since this transfer loop utilizes the split-winding circuit, there is no transfer of information to the upper register during the stepping operation.

The *Exclusive OR* circuit is illustrated in Fig. 6. As is seen from the truth table, the *Exclusive OR* circuit produces

an output when either one but not both of two inputs occur. In order to perform this function, four cores and a cycle of three pulse times are used. However, in many of the applications of this circuit, two of the cores, *A* and *B*, could be part of preceding logical elements and the three pulse times can be reduced to two.

As shown in Fig. 6, inputs p and q can occur at T_1. At T_2 the outputs from cores *A* and *B* are combined in cores *C* and *D*. The double arrow designates an override signal which will swamp out any other inputs to the core occurring at the same time. If an input occurs on p and not q at T_1, then core *C* will be switched to the ONE state at T_2. If an input occurs on q and not p at T_1, then core *D* will be switched to the ONE state at T_2. If signals occur on neither or both p and q at T_1, then neither *C* nor *D* will be switched to the ONE state at T_2. At T_3 cores *C* and *D* are interrogated for an output, s. Thus it is seen that the output s occurs when either p or q but not both occur, performing the logical function of *Exclusive OR*. (Note that T_3 can be replaced by T_1 and the output will occur at the same time as the next input information is being inserted.)

The *Inclusive OR* function, which is an element producing an output for any one of or any combination of several inputs, is formed by simply adding input windings to a single core, or buffering several inputs into a single winding.

One form of a magnetic gate or *AND* circuit is illustrated in Fig. 7. The truth table indicates that a gate will produce an output only for the input combination of a, and b. This circuit consists of two cores and a cycle of three pulse times, with the output occurring at the first pulse time of the cycle succeeding the one in which information is inserted.

The *E* core is preset to the ONE state at T_1 and the *F* core is interrogated for output ϵ at this time. Inputs a and b can occur at T_2, and at T_3 transfer between the *E* and *F* cores takes place. If a occurs and b does not, no output can occur at T_1. If b occurs and a does not, the transfer at T_3 will prevent an output at the next T_1. If both a and b occur, the transfer at T_3 will be prevented and an output will occur at T_1. Thus an output occurs only for both a and b and the circuit performs the logical *AND* function.

In the circuits just described only single cores have been coupled by transfer loops. It is possible to couple many cores together so that data from one core may be transferred into a number of cores. Depending on the application one core can drive five or six others. This facility greatly expands the usefulness of the core in data-processing systems.

APPLICATIONS

WITH THE LOGICAL BUILDING BLOCKS just described, any portion of a data-processing or control system can be constructed; timing control, input-output, arithmetic, and memory sections have all been designed and implemented. It will only be possible to describe a few of the more obvious examples.

Most systems require a timing section to generate control pulses for the various operations that are to be performed.

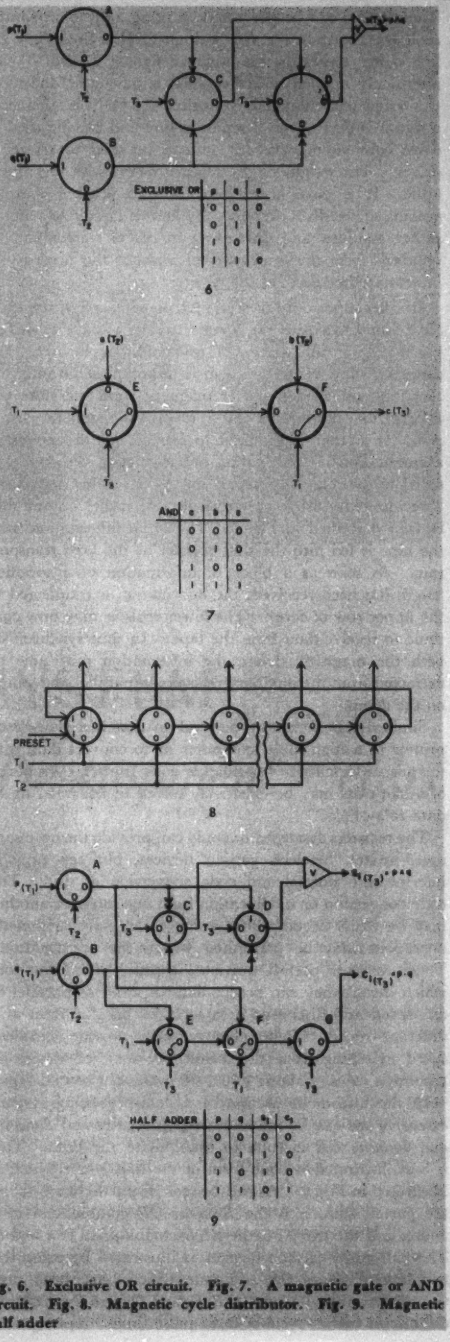


Fig. 6. Exclusive OR circuit. Fig. 7. A magnetic gate or AND circuit. Fig. 8. Magnetic cycle distributor. Fig. 9. Magnetic half adder

These pulses can be generated by using a cycle distributor such as is shown in Fig. 8. A single ONE is preset into the first core; thereafter the advance signals T_1 and T_2 are alternately applied and the ONE is advanced down the chain and recirculated. Each time the ONE is advanced, a signal is derived on a separate line and can be used to drive core circuits directly or can be used to trigger a driver. The length of the register determines the repeat cycle. It is possible to skip cores to achieve unequal spacing of signals if desired. By known circuit techniques rather complex and different patterns of signals can be obtained from the same register without the necessity of increasing the length of the register.

In the input-output sections, magnetic shift registers have found extensive use for the storage of data as well as for matching the speeds of asynchronous devices. For example, suppose the problem is to accept serial information from punched paper or magnetic tape and store this information in parallel on a revolving magnetic drum. A buffer storage is required to provide for the necessary accumulation of information and to match the low tape speed to the relatively high drum speed. This may easily be realized by using the serial input-parallel output shift register described in Fig. 5. The serial information from the tape is fed into the shift register at the tape transport rate. As soon as a block of information of a specified length has been received, the information is transferred to the upper row of cores. The lower register may now continue to receive data from the tape. In time synchronism with the magnetic drum, the information may now be extracted from the auxiliary registers in parallel and stored on the drum.

Similarly, buffers may be used to match a slow-speed printer to a high-speed computer or to convert data into the proper format for a parallel or gang printer. Problems of a like class may be effectively solved in telemetering or data relay links.

The registers described not only can provide the necessary speed match between various devices, but can provide intermediate storage and code conversion as well. The code conversion or modification from one mode to another may be easily accomplished using cores, since arithmetic operations may be performed within the register itself. These registers permit universal transfer of information, which means they can accept data in serial or parallel at one speed and discharge it in serial or parallel form at a different speed. These core registers provide excellent speed matching from the lowest key-operated device to repetition rates of about 1,000,000 cycles per second (cps).

In the arithmetic section of a data-processing system, extensive use can be made of magnetic gates and *Exclusive* and *Inclusive OR* circuits to manipulate the data. This is best illustrated by one form of the half adder which is illustrated in Fig. 9. As can be seen from the truth table, the partial sum, s, is the *Exclusive OR* combination of p and q, and the carry c is the *AND* combination of p and q. The half adder is then formed as illustrated by using the magnetic *Exclusive OR* and gate which have been previously described. Cores A, B, C, and D form the *Exclusive OR* circuit with a cycle of three pulse times; inputs p and q occurring at T_1, combination at T_2, and the output s at T_3. Cores E and F form the gate or *AND* circuit with the inputs occurring at T_2 and the output at T_1 of the next cycle. The G core has been added so that the carry output c occurs at the same clock time as s but delayed by 1 cycle. This is necessary so that the carry generated during 1 cycle can be added to the sum bit generated during the next cycle when two identical half adders are placed in cascade to form a full serial binary adder.

Extensive use has been made of cores in memory systems. The Burroughs memory system for the ENIAC computer, the coincident current memory systems for Whirlwind and BISMAC have all been described in the literature. Many of the new computers that soon will be or are now on the market have high-speed magnetic-core memories.

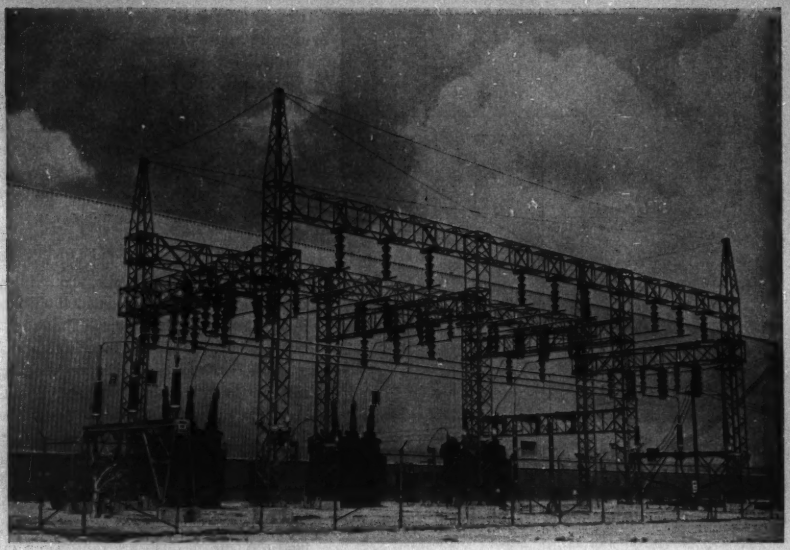
Complete information-processing systems have been demonstrated that operate at a top pulse repetition of 150,000 cps. Specific circuits and portions of systems have been demonstrated in the frequency range around 1,000,00 cps. At these high frequencies reliable circuits have been designed, but the pulse power usually becomes quite high. To date the most efficient operating frequencies have been below 150,000 cps.

An example of the efficiencies that can be gained by "magnetizing" an electronic data-processing system may be cited. The electronic system required 530 vacuum tubes; the core or BIMAG version, 50 tubes and 800 cores. The vacuum-tube version required about 2 kw of power; the core version, 500 watts. The volume reduction was greater than six to one. The over-all reliability should be increased by a factor of at least ten.

CONCLUSION

IT IS NOT TO BE ASSUMED from this discussion that cores are a panacea. They are not. Pulse power is required to drive these circuits, and the driver power increases as the repetition rate increases to overcome the core losses and to insure positive and reliable switching in shorter times. The core itself requires only a few milliwatts of average power to change its state, so that much remains to be done to achieve greater pulse power and at the same time reduce the driver stand-by power. Vacuum and gas tubes, transistors, and magnetic amplifiers have all been used as drivers for core circuits; it is the last two which hold the most promise for the future.

However, there is no available electronic component that has the potential reliability and life of the core. It is unaffected by normal operating temperatures and humidity, and can withstand extreme shock and vibration. In the more than 6 years of application of cores, tests have not exceeded its life span or found the component in failure. For discrete circuits that require microsecond or millisecond operation as well as very low operating and stand-by power, the core should be considered among other available electronic components. As better materials become available and as its use becomes more widespread, the core will eventually find its proper place not only in electronic computers, but also in the fields of industrial control and communication where its possibilities are unlimited.



POWER SYSTEM

Arnold Engineering Development Center

D. J. GOODMAN
ASSOCIATE MEMBER AIEE

The electric distribution system described began operation in October 1952. As designed and built, it has given every indication of its ability to fulfill its requirements and also of being capable of modification as conditions change.

NEARING COMPLETION in central Tennessee is a U. S. Air Force facility, The Arnold Engineering Development Center (AEDC). Conceived during World War II as a necessary adjunct to research centers in the effort to maintain superiority in the air, AEDC has been designed to perform developmental testing on aircraft, aircraft propulsion units, and guided missiles of the present and the future.

Under simulated flight conditions of altitude and temperature, test items can be subjected to wind velocities in the range from subsonic to hypersonic—subsonic being below the speed of sound, and hypersonic the region above five times the speed of sound.

To create the necessary conditions in the test cells requires the use of a great amount of power. One reason for locating AEDC in central Tennessee was the availability of large blocks of electric power from the Tennessee Valley Authority (TVA). Four transmission lines operating at 161 kv will supply the estimated maximum demand of 388,000 kw. The annual usage of energy when in full operation is expected to be 780,000,000 kwhr.

AEDC is comprised of three major testing facilities: the engine test facility and the ram jet addition to the engine test facility, the gas dynamics facility, and the propulsion wind tunnel. It has not been contemplated that the three test facilities would operate simultaneously; therefore, the electric distribution system was designed to carry the load of the largest of the three, the propulsion

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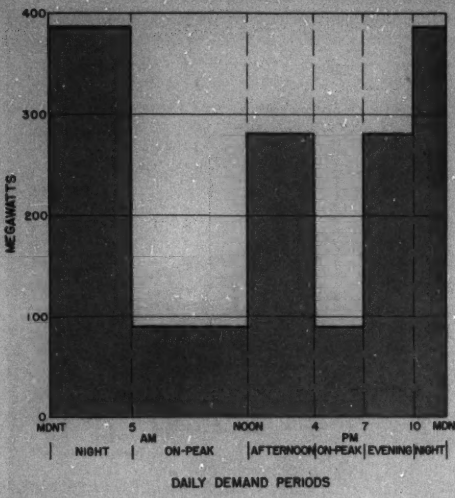


Fig. 1. AEDC maximum power requirements during daily demand periods

wind tunnel, operating by itself. The simultaneous load of the other two test facilities is less than the power requirement when the propulsion wind tunnel is in full operation.

For reasons of economy and availability, the maximum use of power has been scheduled for the night hours. The operation of the other test facilities will be scheduled to fit into the daily load curve of the TVA system. By agreement with TVA, the demands during the various periods of the day will not exceed the limits shown in Fig. 1. The scheduling of operations will result in the heaviest use of power between the hours of 10 p.m. and 5 a.m. Between 5 a.m. and noon the load will be reduced to approximately 25 per cent of the night maximum; from noon to 4 p.m. the simultaneous operation of two testing facilities will require approximately 70 per cent of the maximum; over the utilities' evening peak from 4 to 7 p.m. the power requirement will be reduced again to the morning level; and then from 7 to 10 p.m. the load will again increase to 70 per cent of the maximum. Thus, the operation of the test facilities will be scheduled so that the use of power will fit into the load curve of the TVA system. In order to do this, testing operations will be carried on around the clock.

DESIGN OF DISTRIBUTION SYSTEM

LARGE BLOCKS OF POWER are required for the operation of individual test facilities which are located geographically in a relatively small area. That fact had a considerable bearing on the design of the distribution system.

Main Substation. At the present time, three TVA transmission lines terminate at the AEDC main substation. A fourth transmission line will be required by the end of 1957. Rated at 154 kv, the bus voltage will normally be in the neighborhood of 161 kv. The dispatching board in the main control room in the power control building is shown in Fig. 2. In addition to the three TVA lines which terminate on the AEDC bus, there are three outgoing circuits which feed the central facilities transformer no. 1 and two underground cable circuits *UG 91* and *UG 92*. At times when the AEDC load does not require the full capacity of the transmission lines, power can be fed through the AEDC bus from one part of the TVA system to another. One of the seven 161-kv oil circuit breakers is a transfer breaker equipped with a full complement of relays so that it may be substituted for any of the other six. The addition of the fourth transmission from TVA will require that all of the breakers in the main substation be of the 10,000,000-kva interrupting capacity class. The line breakers are equipped with automatic reclosers; the feeder breakers are not so equipped.

The central facilities transformer reduces the voltage to 13.8 kv and has two secondary windings. A Y-connected

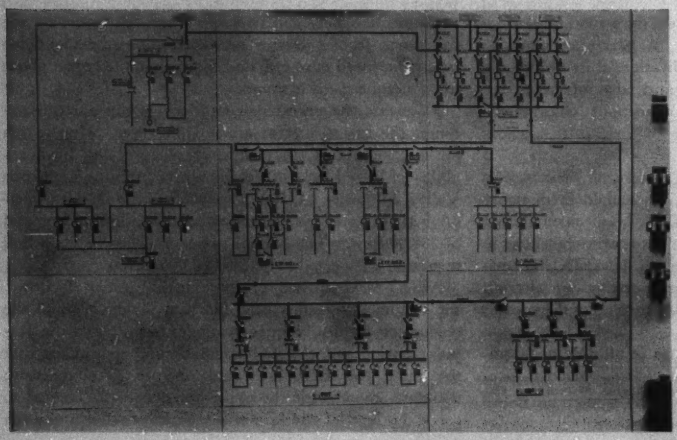


Fig. 2. Dispatching board in the power control building at AEDC. The 161-kv system shows up as the heavy black lines. Total length of underground cable operating at 161 kv is approximately 8,000 feet

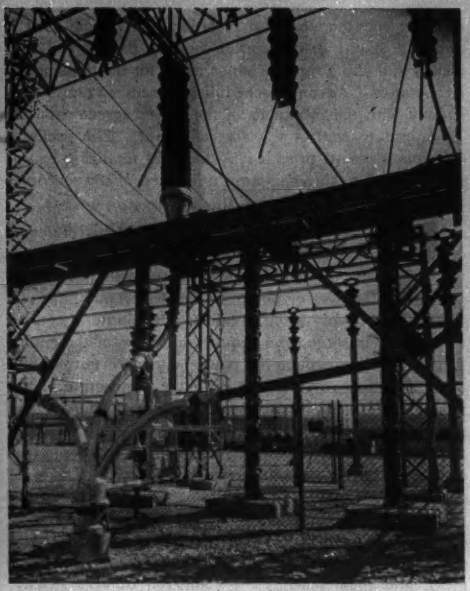


Fig. 3 (left). Spreader head at terminal of 161-kv pipe-type cable. Oil pressure maintained at 200 psig. Capacity of cable 225,000 kva Fig. 4 (above). Load recorders located in the power control building provide the dispatcher with a continuous record of the tee facility loads. The middle recorder on the right shows the rate-of-change in megawatts per minute for the total AEDC load

winding feeds a 13.8-kv underground and overhead distribution system which supplies all of the lighting requirements of the Center and all of the power requirements that are not directly associated with the installed equipment in the test facilities. The largest power loads supplied from the 13.8-kv system are the two water pumping stations, whose combined pump motor capacity is 18,950 hp. A delta-connected secondary winding is connected to a hydrogen-cooled synchronous condenser rated 36,000 reactive kva at 15 pounds hydrogen pressure.

Lightning protection is provided by static wires installed to provide a 30° cone of protection over all overhead lines and substations operating at 161 and 13.8 kv. In addition, lightning arresters are installed to protect all transformers and underground cables.

161-Kv Cable System. Power for testing operations is delivered to the test facilities by means of an underground cable system operating at TVA's transmission voltage. The 161-kv cable system forms a loop circuit from the main substation to the test facilities with four step-down substations as a part of the loop and with two short radial feeders emanating from two of the loop substations. Approximately 500,000 kva of transformers reduce the voltage from 161 kv to utilization voltage of 13.8 and 6.9 kv. A typical step-down substation, see title picture, supplies 100,000 kva at 6.9 kv to the main drive motors of the gas dynamics facility. The 161-kv cable system is normally operated as two radial feeders rather than as a closed loop. Overhead static wires provide 30° cone of projection against lightning.

The pipe-type cable system has a total length of 9,000 feet made up of seven lengths of underground cable with terminations as shown in Fig. 3. The underground installation is comprised of three 1,500,000 circular-mil cables in a $8^{5}/_{8}$-inch outside-diameter steel pipe. The pipe is filled with oil and kept at an operating pressure of 200 pounds per square inch. The cable itself has 650 mils of impregnated paper insulation and for protection after manufacture was encased in a polyethylene sheath having a thickness of 65 mils. The polyethylene sheath was not removed during installation thus providing permanent protection to the cables after installation.

A pilot-wire protective relay system is employed to protect the 161-kv distribution system. In addition, a method of transfer tripping is used to route trip signals from the remote substations to either of the two 161-kv feeder circuit breakers.

OPERATION OF THE SYSTEM

A WIND-TUNNEL TESTING FACILITY such as AEDC has load characteristics which set it apart from the ordinary and which from the utility point of view require special considerations and restrictions. For example, an emergency shutdown of approximately 388,000 kw load could have serious consequences on a utility system even as large as TVA's. In order to prevent, or minimize, disturbances on the TVA system, the dropping of loads in excess of a predetermined amount will initiate a carrier-current signal which can be used to trip certain hydro units on the TVA system—the number of hydro units depending upon the magnitude of the AEDC load and the amount of load dropped. Another precaution will be to distribute the load

to limit the amount of load that could be dropped by the tripping of any one AEDC circuit breaker to 200,000 kw.

Limiting Rate of Load Change. Another important consideration that had to be taken into account in the design of AEDC which will require constant vigilance in operation is the limiting rate of acceleration and deceleration of load that the utility can tolerate. This limit has been set at 20,000 kw in 40 seconds whether gradual or in steps. Each individual facility has been designed to permit normal operation within this limitation. Rate-of-change meters are installed in each test facility for that facility's load and in the power control building at the main substation for the total AEDC load. The rate-of-change meters are of both the recording and indicating type. The load dispatcher in the power control building has the responsibility of scheduling and authorizing load changes in order to prevent the total AEDC load from exceeding the prescribed rate of load change. When a facility is operating with support from other facilities (for example, the propulsion wind tunnel will at times be supplied make-up air by the engine test facility while at the same time the ram jet addition is scavenging from the tunnel), it will be the responsibility of the facility running the test to monitor the operations of the other facilities supporting it so that the prescribed limitations are not violated.

Power Factor. The "Memorandum of Understanding" between the TVA and the U. S. Air Force provides that AEDC shall maintain a power factor of not less than 98 per cent lagging. The motors in the engine test facility are all wound-rotor induction motors. In the other test facilities, the main drive units are a combination of synchronous and induction motors. The induction motors are for starting and also share the load when the power requirements of the compressors exceed the capacity of the synchronous motors. The latest addition to the propulsion wind tunnel has been designed for unity power factor on the high side of the 161-kv transformers supplying it. Out of approximately 600,000 hp of main drive motors, ranging in size up to 83,000 hp, the division between synchronous and induction is approximately 75-per-cent synchronous and 25-per-cent induction. In order to maintain 98-per-cent power factor, the hydrogen-cooled synchronous condenser previously referred to has been installed in the main substation.

Load Scheduling. The magnitude and irregularity of the loads at AEDC require careful scheduling in order that TVA may be prepared to supply them. A tentative schedule of hourly loads is submitted to TVA a week in advance and confirmed or revised a day in advance. It is also necessary that the schedule be confirmed or revised prior to each major change in the schedule or in the level of use.

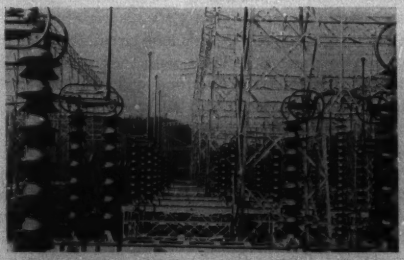
Load Totalizing Equipment. To assist the AEDC load dispatcher in the difficult job of monitoring the loads of two or more test facilities operating simultaneously, the load totalizing equipment shown in Fig. 4 has been installed in the power control building. One recorder is provided for each test facility, one for central facilities, and one for the total AEDC load. A rate-of-change recording meter operates from the total load recorder. Each facility has a duplicate of the load recorder showing the load of that facility and also a rate-of-change meter for the guidance of its operators. Advanced scheduling of loads is a necessity to comply with the provisions of the power agreement with TVA and to control the cost of power. The accurate continuous record provided by the load totalizing equipment is vital to the maximum utilization of the schedules as set up.

Continuity of Service. Continuity of service is of major importance at AEDC. Loss of power while testing operations are being carried on may ruin the tests that are in progress. The loss of power to the water pumping stations, which supply 150,000 gallons per minute of cooling water, may in some cases require shutdown of the equipment. An interruption of power under certain testing conditions may result not only in the destruction of the model being tested, but also under extreme conditions may seriously damage the tunnel. These possibilities were taken into account in the design of the electric distribution system. The necessity of avoiding enforced outages of equipment constitutes one of the reasons for an exacting preventive maintenance program based upon the best practices in industry today. Periodic inspections and tests have been scheduled for every piece of electric equipment, and these schedules are adhered to very strictly. The results of the scheduled inspections and tests are reviewed by competent engineering personnel who recommend remedial action where indicated.

CONCLUSION

THE AEDC ELECTRIC DISTRIBUTION SYSTEM was placed in operation in October 1952. Since that time one test facility has gone into full-scale operation, a second one is undergoing calibration, and a third will begin shakedown before the year is out. The system as designed and built has given ample indication of its ability to fulfill its requirements and lend itself to modification to meet changing conditions.

Power for Portsmouth Project



Part of the substation at Clifty Creek power plant, Madison, Ind., showing R and IE 330-kv switches installed and inspected, ready for service.

Automation—A Survey

R. J. BIBBERO *
MEMBER AIEE

Detroit automation and job-shop automation are contrasted, as well as several other types of automation described, in this article. Factual aspects of automation, covering history and engineering factors, are presented.

THE WORD "AUTOMATION" has certainly become controversial. Along with many other respectable branches of technology, such as nuclear physics, it has entered the political arena, which appears to be one sign of technical success. To begin with one should take a look at the word itself to see what the argument is about.

Many experts, like Norbert Wiener, refuse to use the word at all. He prefers "automatization," which is a little difficult to pronounce. J. J. Brown of Canada uses "mechanized," "automatic," or "cybernetic" to express different degrees of progress on the road to automatic production.

Gordon Brown of Massachusetts Institute of Technology has linked automation with the concept of feedback in the automatic control art. According to him, "Automation is the use of this art to increase production, improve quality, and reduce the amount of human muscle needed in manufacture."

John Diebold, editor of *Automatic Control* magazine, used the word even more generally in his book "Automation." He defines it as "both automatic operation and the process of making things automatic."

Whichever definition is preferred, it is certain that many techniques and functions must be lumped under the name. These included the design of mechanical, electric, and electronic machinery; product and process redesign; and the theory of communications and control.

Because the concept of control, and particularly feedback control, is the basis of automation, its growth has paralleled the growth of electrical engineering science, since electrical control is the most highly advanced and economical of all methods.

The manifestations of automation are taking many forms and are becoming vastly more numerous. They range from simple devices to maintain room temperatures at a comfortable level to multimillion-dollar guided-missile systems, such as NIKE. Other automation systems are controlling entire oil refineries, machining jet-turbine blades from punched-card programs, or computing the payroll of a large factory within a few hours.

All facets of automation have the same aims: to reduce costs, speed up production, and improve quality by eliminating human fatigue and error. These goals are by no means new, nor is automation itself. In fact, if one looks at the history of automation, one may wonder why it has taken so long to catch on.

Nature was one of the earliest users of feedback control. The mechanism that maintains body temperature at 98.6 F is a feedback process, one of many in the body. This kind of physiological regulation is called "homeostasis." Another example of a human feedback mechanism is the hand-and-eye co-ordination which permits one to grasp an object. Norbert Wiener has shown that this mechanism is subject to the same kind of oscillatory troubles as a mechanical feedback system.

Apart from the inventions of nature, about the first reference found to a device coming under the general head of automation is an automatic door opener, invented in the second or third century B.C. Hero of Alexandria, who also invented the steam turbine, created a mechanism used to open temple doors when a fire was lighted on the altar. He allegedly accomplished this bit of magic by means of a steam boiler on the altar which induced steam pressure in a piston linked to the door. There is no feedback here, but one must admit that this is as much a legitimate automatic device as the "electric eye" which opens doors.

The ball-float valve, which controls the water level in plumbing, was an ancient invention of the Romans. Similarily, the pilot windmill which drives the main sails automatically into the wind is an invention lost in the history of Holland. Both of these can be classified as feedback "automation" without stretching the term.

In historic times, the first recorded use of punched paper tape—currently associated with teletypewriter machines, digital controls, and computers—was by Robert Hooke in 1670. He utilized this medium to record the output of an automatic weather station, including a rain gauge, wind gauge, and a clock.

Watt's invention of the flyball governor in 1788 was not only in itself a milestone in automation, but was responsible for Maxwell's classical analysis of a feedback system and the beginning of automatic control theory. Other significant automatic machines followed rapidly—Evan's flour mill in 1784, the Jacquard punched-card controlled loom in 1801, and Babbage's attempt at a punched-card computer in 1833.

In modern times, ship-steering systems provided one of the first sophisticated large-scale applications of feedback control. Their mathematical analysis by Minorsky in 1922, followed by the work of Nyquist, Black, Hall, Hazen, and others in the 1920's and 1930's, put the servomechanism theory on a firm basis. The climax of this work was reached during World War II when the Office of Scientific Research and Development instigated a marriage between advanced

Condensed text of a paper presented before the New York Section of AIEE, March 9, 1955, and recommended for publication by the AIEE Committee on Feedback Control Systems.

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electrical feedback theory and the servomechanism art which resulted in high-performance fire-control and gun-laying systems, automatic tracking radar, and guided missiles.

POSTWAR SYSTEMS

Now the emphasis has returned to mechanized production techniques. Automatic production of goods has taken two main roads depending on the nature of the product. One road is that followed by the process industries, such as petroleum and sugar refining, steel making, and paper making, where the product is in the form of a continuous flow or stream. In each portion of the process, some variable such as temperature, pressure, or speed must be maintained at a set value. Automatic control, in these cases, has taken the form of regulation and the devices used to maintain the proper condition in any process are known as regulators.

The other path to automatic production is that taken by the fabricating industries. By these is meant industries in which multiple operations are performed on a discrete workpiece, and the finished pieces assembled into a complete product. The obvious example of this type of operation is automobile manufacture. Automation in the fabricating industries descends literally from Evan's automatic flour mill. Automatic tools such as screw machines, turret lathes, and multiple-head boring machines, which perform one or a few operations rapidly and in fixed sequence, need only be linked by conveyors and loading mechanisms to form a completely automatic assembly line. Because this kind of automation is closely associated with the automotive industry, it is referred to as "Detroit automation."

The growth of automation in the process industries was initiated in the 1920's. Today, in the petroleum industry alone, there are more than 50,000 regulators and controllers, without which refineries could not operate. Because of the round-the-clock efficiency of automatic controls, the cost of gasoline today in only slightly more than in 1920, in spite of the changes in dollar value and the ever increasing labor costs.

Fabricating-industry automation depended: first, on the invention of interchangeable parts and the assembly line—both by Eli Whitney in 1798; second, on the development of high-speed automatic machine tools; and, lastly, on their integration by means of automatic conveying and handling machinery.

Today's outstanding examples of Detroit automation are found in the Ford Motor Company's well-known Cleveland engine plant and in the Rockford, Ill., Ordnance plant for 155-mm shell production. Another example is Ford's latest assembly plant, which is opening at Mahwah, N. J.

All automation of the fabricating industries is not of the Detroit variety, nor is it limited to metal working and machinery. In the first place, an entirely different kind of automatic production of discrete products is possible using individual machine-tool control, without the need for assembly-line techniques or long production runs; this kind of job-shop automation will be discussed later.

In the second place, another kind of discrete product has been the subject of extensive and well-publicized automation recently—automatic production of electronic equipment.

The development by John Sargrove, a British engineer, of automatic equipment for the production of radio receivers, was the earliest of these systems.

The present kinds of automation therefore include several types: First of these is the Detroit variety, characterized by special-purpose machines, operating on discrete parts, and linked by materials-handling conveyors and transfer mechanisms. The high initial costs and long single-product runs required by Detroit automation can only be afforded by a few major industries.

Second, discrete products can also be handled by smaller and more versatile machines such as milling machines, drills, punch presses, and the like. These individual machines can be automated by servomechanisms and tape or contour-following control, to make up what may be called "job-shop automation."

A third type of automation is the mechanized assembly of standard components, exemplified by the production of electronic equipment. The components may be fabricated by the machine itself, or be derived from another machine, in which case the assembly machine must be designed specifically to handle the components, rather than conversely.

Continuous process control is another kind of automation, and one that is firmly entrenched in our economy. The proportional controller or regulator used in the petroleum and chemical industries is a kind of analogue computer. Its objective is to maintain the value of a single variable, using measuring instrumentation and feedback control. More sophisticated analogue computers may be used to exercise supervisory control over a number of regulators in order to optimize an end product rather than control a single variable.

Another type is business automation. Much clerical labor is repetitive and tedious as is some factory labor, and can be eliminated by machines capable of following fixed orders. The digital computer is such a machine and is rapidly being introduced into the business world after being used in scientific and mathematical computations.

Finally, in order to provide a link between the digital computer and the human operator an automatic communication device is needed, which can speak the language of the computer. For example, the point-of-sales transmitter is used in retail department stores to transmit sales and inventory data. The extension of this idea to factory warehousing, time-keeping, and job production data will grow as the use of automatic computers for central records keeping becomes more common.

DETROIT AUTOMATION

For the Detroit variety of automation, the Ford engine plant, which is functionally one large integrated machine, has already been mentioned. The Ford plant is so closely identified with materials-handling machines that Mr. Harder, vice-president in charge of manufacture, coined the word "automation" to describe the automatic handling of work in and out of the machines.

Ford's goal, reduction of manual handling, has been achieved with such success that one operator's job has been

altered from that of lifting 50,000 pounds per day to that of reading dials and pushing buttons. A production line turning out 154 engine blocks per day has reduced its labor requirements from 117 to 45 men.

Ford is not the only company that has introduced this kind of automation. One of the newest automatic engine lines is Packard's at Utica, Mich. Their 1,100-foot line handles 50 blocks an hour and performs 385 operations. The blocks undergo over 200 inspections and are automatically ejected from the line if they do not meet tolerances. The line was designed by Packard engineers to operate in 14 electronically controlled groups. It required 7 months to set up and cost about $22 million.

The cost of this kind of automation to Ford and General Motors has been put at $50 million each. It has been claimed that the capital requirements to compete with these automatic machines was a major factor in the merger between Studebaker and Packard.

In another field, the Hatau Engineering Company has built a machine for Thompson Products in Cleveland, Ohio, which produces jet-engine starter housings in 3 minutes and 20 seconds, compared with 56 hours of conventional machining. The cost of production has been reduced from $1,200 to $0.90 per unit. The machine is a combination of a multiple head borer and milling cutter, controlled by a programmed device.

Hatau has also been active in advocating the use of continuous strip feed for high-speed production of punched parts. The objective is to eliminate handling of loose parts and conveyors by utilizing the metal strip itself to transfer the work. Another advantage is the saving in material if the product is properly redesigned to take full advantage of strip feed. It is interesting to note that strip feed comes very close to continuous processing in the chemical and petroleum refining sense. The closer a continuous flow of materials is obtained, the easier it is to implement automatic production.

JOB-SHOP AUTOMATION

Detroit automation requires a very high capital investment, and except for rare applications, is suitable only for long production runs of the same product. It is not a particularly new phenomenon, but is rooted in the whole history of mass production.

There are very large segments of production for which this type of automation is not at all suitable, even though it deals with discrete products. One of these is job-shop production, where the length of the production run is not sufficient to set up a mass production line. Another type is exemplified by airframe manufacturing, where a production line exists, but models are changed frequently, and a high degree of flexibility must be maintained. Military orders, at least those of a prototype nature, are another class in which a high production potential must be planned, but this potential is held in reserve until the event of emergency.

To reduce routine labor, to improve product quality and uniformity, to eliminate spoilage, and yet to maintain machine flexibility—all this within the budget of a comparatively small shop or department—is the challenge which automation is attempting to meet today. The answer lies in job-shop automation—the automatic control of multipurpose machine tools such as lathes, drills, milling machines, and punch presses. These are the machines which are capable of performing the majority of metal production jobs which come into the shop. If the machines can be successfully equipped with simple accurate positioning controls, and flexible programming devices, industry will have gone a long way toward complete automatic production.

Detroit automation is largely a matter of transporting work between and feeding it to a line-up of specialized machines. The automation of individual machines, on the other hand, is a matter of positioning the work or tool after it is in the machine. The positioning must not only be accurate, but rapid.

The kinds of positioning mechanisms available can be divided into analogue and digital types. The relative virtues of each are fairly well known. Generally speaking, analogue devices are accurate to 0.1 per cent of the unambiguous base measurement, while digital mechanisms may have accuracy limited only by the desired reading or counting speed. Analogue controls can handle complex problems more rapidly and easily, and can thus compensate for inertial loads and some kinds of friction. Digital devices are less influenced by noise and crosstalk in the controls than are analogue ones. They are more flexible and can even be used for several different functions in a time-shared basis.

More important to machine control, digital devices are easier and cheaper to program for short-term jobs. For example, it may well be economical to make up a punched-tape program for a run of 10 or 20 identical pieces, where an accurate cam might require thousands of pieces to pay its way. In general, the cost curve of analogue controls rises linearly with complexity, while that for digital controls is fairly flat. But lastly, and probably most important, the error in analogue machines increases gradually with wear and other degradation, while that of digital equipment does not increase until a catastrophic failure occurs. In some types of control, for example the operation of an expensive or hazardous process such as oil refinery, catastrophic failure cannot be tolerated, hence analogue control is indicated. In machining, however, the undetected increase of small errors is less desirable than a rare but complete shutdown, which tends to favor digital control.

Some well-known examples of individual machine tools having analogue control, or essentially the characteristics of analogue control, include Arma Corporation's automatic lathe, and General Electric Company's record-playback system. The former utilizes punched-tape input, and the latter magnetic tape, but both rely ultimately on a synchro-servo system for position control. The General Electric system has the unfavorable characteristic that backlash accumulated since the tape was recorded is not compensated in later playbacks, so that errors may gradually accumulate.

The Massachusetts Institute of Technology's numerically controlled milling machine takes its command from a binary-coded punched tape, and the information flow remains digital up to the hydraulic lead-screw servomech-

anisms. After this point, control is again in analogue form, the feedback and input elements being conventionally used selsyns.

PURELY DIGITAL CONTROLS

Of the purely digital control systems, the General Electric programmed punch press was one of the first. Digital dimensional data are transferred from punched tape to a counter, where it is compared with the pulses derived from an accurate engraved glass scale mounted on the work table and moved under a photocell detector. The table is then stopped when the count is satisfied. In a similar British system, diffraction gratings are used for the scale, and applied to the control of a milling machine.

Another type of pure digital control is based on a powerful stepping motor which can directly operate the positioning lead screws of a milling machine. The motors step once for each pulse applied, each step representing a definite degree of rotation. The positioning pulses are derived from a 35-mm punched plastic tape.

Although purely digital control is less limited in accuracy, it does not of itself solve problems associated with the load inertia. If a machine is operated at full speed by means of pulses, or if, as in the General Electric system, pulse feedback to a preset counter determines the length of travel, the machine does not stop when the pulse count is satisfied. The inertia causes a certain amount of runout. When a pure counting system is used, there is no simple way of accounting for the runout, and its effects can accumulate and lead to a large error.

For example, in a hypothetical digital system, the present dimension may be stored in one counter and the next desired dimension in another. If clock pulses are fed to both counters, the one which is first run up to zero determines the direction of travel and the remaining counter will store the differential motion required. If the second counter is satisfied by moving the work table or the tool, and by feeding back pulses from a simple coder, a "stop" command can be derived. But if the table runs out a few more pulses before stopping, one has the problem of accounting for them in the next move. If the next move is forward, the pulses must be stored and subtracted. If backward, the count must be added. Altogether there are four possible cases, and the system rapidly becomes very complicated.

There are two ways to avoid some of these troubles. One is by providing an internal reference scale which keeps track of at least the higher-order digits. In other words, all dimensions are measured from a reference point, rather than the last dimension. This means the higher-order digit desired must have unique characteristics. Another means to avoid overrun is to provide anticipation before a stop command so that the machine is slowed down before it is stopped.

Hillyer Instrument Company has used both these methods to create a machine-tool control that is simple and accurate and approaches the characteristics of the ideal on-off servo. Applied to an automatic locating and drilling machine, the system uses both a 2-speed electromechanical motor control with anticipation and an accurate internal reference scale, operating from uniquely energized electric contacts. The work and drill head are simultaneously located by means of two similar servos in the X and Y dimensions, in increments of 0.001 inch over a 24- by 24-inch area. One feature of the machine is that it can be operated either from a manual console or from a tape reader. The tape is a heavy vinyl plastic containing 14 decimal channels or 140 bits. In the manual operating mode the operator dials in the appropriate dimensions by reference to a chart prepared from the blueprint and starts the machine after hitting a forward or reverse control to choose the least travel time.

The drill was originally designed for medium-accuracy-template spot drilling and chassis layout work. In actual use over a number of months, it has cut down layout time on a 2-hour job to 11 minutes. The larger version of the machine takes up to a $^1/_2$-inch drill size and can be used for heavier and more accurate work. The same type of control can be applied to any machine which requires positioning of a work table.

ELECTRONIC ASSEMBLY

One of the most interesting aspects of automation is the trend toward mechanized production of electronic equipment. The situation in the electronic industry until now has been a paradox. Although much of the automatic-control equipment used in other industries has been electric or electronic, the techniques used for assembling the control equipment itself have been those of laborious hand-wiring. Wilson Hannahs, in a recent article published in *Proceedings of the IRE* (Institute of Radio Engineers), has aptly characterized the situation as that of "the shoemaker's child unshod."

Mechanized electronic production obtained its start from the unprecedented requirements of military electronics in World War II, particularly those of the proximity fuse. The goals sought were small size, ruggedness, reliability, and producibility. A rethinking of the product requirements led to the development of new techniques such as printed wiring and dip-soldering, together with the development of miniaturized components.

Fortunately the solutions to the problems of miniaturization and reliability also led naturally to the possibility of mechanized assembly. A series of investigations carried out by the Bureau of Standards, among others, led to the development, first, of miniature intermediate-frequency strips using tape resistors and, finally, to the Modular Design of Electronics (MDE) and Mechanized Production of Electronics (MPE), also known as Project Tinkertoy.

More recently, the demand for color television sets, requiring more than 40 tubes and twice the component density of black-and-white sets, has spurred the introduction of automation into the civilian electronics market. The pressure toward cost reduction of color television means that every possible opportunity will be taken to automate production.

There are two general approaches to the automatic production of electronics. One concerns component and process redesign and the other, mechanized assembly. Printed circuits and Tinkertoy modular construction repre-

sent the first category. The printed, stamped, or otherwise preassembled wiring is inherent in most electronic automation, since the hand-wiring process is the most time-consuming operation. Sargrove's original machine was based on the concept of sprayed wiring. The National Bureau of Standards' (NBS) contribution was: (1) the concept of the standard module—a $^{7}/_{8}$-inch-square ceramic building block which carries the wiring and components; and (2) the tape resistors and miniature titanate capacitors, which with the ceramic module are adaptable to automatic assembly.

The other facet of automatic electronic production is mechanized assembly of standard components. The approach of Tinkertoy was to design as many of the components as possible for printing, stamping, or cementing to the steatite base, so that automatic assembly almost falls out of the design. In the present state of component technology, this is a somewhat severe limitation on the designer, since most of the components in use today are of the conventional axial-lead design. To assemble conventional components automatically is a mechanical positioning problem.

Given a printed-circuit board, produced by silk-screen, lithographic, or other technique, the problem is to handle the components, straighten and trim leads, bend them over, and position the components over the correct spot on the board.

The printed circuit, with holes drilled into its wiring at the right spot to receive component leads, must be moved under the component head at the correct moment before the component is inserted. The preparation and indexing of boards and components must be done rapidly and accurately for a large variety of components—resistors, capacitors, transformers, tube sockets, and so on.

This kind of automation is the Detroit variety, in that indexing is accomplished by mechanical stops, and programming is according to a present cycle. Although this kind of assembly machine is flexible, in that it can be set up to produce almost any kind of circuit, a certain amount of expensive make-ready time is required to set up the line.

Some of the earlier work in the component handling field was accomplished by Battelle Memorial Institute under Air Force contract. They developed machinery automatically to test axial-lead components at high speeds. The components can be dumped into a hopper, and the machine straightens the leads and inserts them into bridge terminals so that their value can be measured while being transported through testing chambers.

The Stanford Research Institute also has carried out very broad studies of automatic printed-circuit assembly, under Freeman Hom and W. K. Lee. These studies involved printing methods, dip-soldering, and component layout, as well as the economics of the methods.

The United Shoe Machinery Company has developed an automatic component-insertion machine capable of handling 9,000 boards per 8-hour day. This machine handles resistors, capacitors, and eyelet-type terminals. The components are loaded into belts and then handled in a manner similar to shoe-manufacturing equipment.

The most recent member of the automatic assembly machine family is the Autofab, developed by the Mechanical Division of General Mills. This division is under the direction of Dr. Cledo Brunetti, who developed many of the printed-circuit methods at NBS and directed some of the Stanford studies.

The Autofab was originally conceived as a radio and television production machine. The present model, however, has been sold to the International Business Machines Corporation for the automatic production of military air-defense computers. Each computer requires several thousand printed-circuit subassemblies, and the production schedule could not be met by hand methods.

The capacity of Autofab is 200,000 assemblies per month on a 40-hour week basis, approximately the same as the United Shoe machine. It requires only two operators and a supervisor for operation.

The principal parts of the Autofab are a feeding mechanism for the printed-circuit base plates, 24 attaching heads with controls and component feeders, a conveyor system for moving the base plates along the assembly line, a positioning mechanism for locating the base plates under the attaching heads, and interlocks to insure proper sequencing.

The machine uses multiple magazines for the base-plate feeder and attaching heads, so that no operating time is lost when they are emptied. As each magazine is emptied, a new one is automatically turned into position. The machine is also equipped with interlocks which stop the machine if a hopper is exhausted or one of the units is defective.

General Mills claims several advantages to their system of feeding components from a magazine rather than from a belt or tape. With tape feeding, a splice must be made when the end of the tape is reached. If this is not made at the right time, the line must be shut down. The cost of attaching the components to the tape is eliminated, of course. The circuit cards are also handled without any special mounting, so that a source of positioning error is eliminated. The Autofab uses the same surfaces for positioning the card as are used to guide the equipment which drills the component lead holes.

One problem relative to the assembly of printed circuits is the question of producing holes in the board suitable for the insertion of component leads. Although the circuits themselves can be easily produced by a variety of automatic methods the terminal holes must be either drilled or punched manually or an elaborate fixture made up for gang punching or drilling. The first method is very time consuming and the second requires an elaborate setup which is not suitable for short runs.

An alternate method of alleviating this bottleneck is to devise a job-shop-type machine which can operate from a tape programmer. The Radio Corporation of America recently announced the availability of a device which has been used in their own shops for some time, called the printed-circuit-board programmed punching machine. It is a multiple-head punch which is programmed to suit a predetermined grid of possible holes. This is of course a limitation on flexibility which would not suit every process.

A flexible solution to the problem is one which the Hillyer Instrument Company has developed. This machine is an adaptation of the tape-programmed template drilling

machine. The mechanism is a combination of tape control and a photoelectric sensing head. The general location of the hole will be inserted in the tape program and the sensing head will determine the exact place to drill. Similar circuit boards made from different masters can be accommodated, even though there are slight variations in the actual dimensions. Furthermore, drilling rather than punching means that more than one board can be accommodated at one time, and that smaller holes can be made.

PROCESS CONTROL

Space does not permit deep analysis of the control of continuous processes, even though the automatic chemical plant or refinery is the best entrenched and most highly integrated of all kinds of automation. One outstanding fact about process control—the control of temperature, pressure, chemical composition, and so forth—is that it is almost entirely analogue control. One reason for analogue control of chemical plants and refineries is the degradation factor mentioned earlier. The processes are usually somewhat hazardous and it is much better to put up with some inaccuracy than to have a boiler or chemical reactor go out of control. Another reason for the use of analogues is that the processes are relatively complex; they contain lags and inertia and nonlinearities. This kind of thing is much easier to control by analogue means than digitally because the analogue is closer to the physical reality. Most controllers used in chemical plants are of the proportional type and have provision for introducing derivative and integral compensation. In reality they are simple analogue computers. Their input is an electric signal or mechanical motion or pressure change from a transducer, which itself is an analogue of the variable being controlled. The controller measures the deviation of this variable from a reference and computes a corrective signal which is applied to the valve or other control, which brings the process back to the predetermined state of normality.

The present-day process controller does not attempt to do anything except to keep the controlled variable at a present point. The judge of where that point should be is the human operator. To go a step further, to obtain fully automatic operation, one must go to end-point control. This means that the settings of all the individual controllers should be capable of continuous automatic change in accordance with the nature of the end product. It requires, first, a method of continuously analyzing the end product and perhaps the incoming raw material, and, second, a computer which will be able to take into account all the different variables and determine the optimum setting for each point in the process.

The question of continuous product analysis is rapidly becoming solved by such methods as infrared spectroscopy, mass-spectrometry, and X-ray photometry. These methods are capable of continuous stream analysis of up to eight components at once. The computer itself must certainly be capable of handling a very complex problem and solve it in at least "real time." For these reasons, the master controller will probably be an analogue computer rather than a digital machine.

BUSINESS AUTOMATION

The objective of business automation is to mechanize or eliminate paper work such as records keeping, tabulating, and transfer of information. The annual cost of routine clerical work in the United States is staggering—over $4 billion for the government alone, according to the Hoover Commission. Business and accounting records differ from engineering computations generally, in that they must be absolutely accurate or they are of little value. Hence, business automation is invariably on a digital basis, and is based on the use of digital computers.

Although the most spectacular of these applications, such as the feat of Univac in computing General Electric Company's 15,000-man Louisville payroll in 4 hours, are performed by machines in the $1,000,000 class, there are fortunately many less expensive machines coming on the market. Examples are the Burroughs *E101*, the Marchant "Miniac," and the "Readix" manufactured by J. B. Rea Company. Many other useful examples of business automation do not require computing, but merely involve transfer and storage of information. Teleregister's "Reservisor" built for American Airlines records seating reservations on aircraft flights in a magnetic drum, and makes the information available to ticket agents by means of small remote interrogating consoles. A similar installation in the Toronto Stock Exchange transmits quotations to brokers on demand. The "point-of-sales" recorder, used in large department stores, is another device which merely transmits information but economizes greatly on paper work. These devices read punched cards, which replace price tags on objects which are sold, and record the inventory information on punched tape, where it can be subsequently read out on an automatic typewriter or converted automatically to punched cards for further tabulating. A similar system, designed specifically for industrial uses, such as time-keeping, inventory, and job production data, is being developed by the Hillyer Instrument Company.

CONCLUSION

While there are many factors causing the present well-documented upswing in automation, among them being the competition of other automatized facilities, there are also some limiting influences. Chief among these is the reliability of the new devices. An automatic machine must be more reliable than a manually controlled one, because it produces faster, and without supervision can spoil more work before a malfunction is detected. At the same time, automatic machines are, of necessity, more complex. If the complexity of function is achieved at the expense of more components, industry is posed with a dilemma, since failure rate rises exponentially with the number of components. To combat this trend, much work has been done on checking methods, particularly for computers, and in means for detecting incipient failure. Also, statistical means are being investigated to utilize the multiplexed output of a great number of unreliable components in parallel. But none of these is a substitute for economical design and the use of reliable components well within their ratings. The immediate future of automation may well depend on how seriously designers take these precepts.

Skin-Effect in Bars of Squirrel-Cage Rotors

M. M. LIWSCHITZ-GARIK
FELLOW AIEE

BAR SHAPES are used in rotors of squirrel-cage motors for which a straightforward mathematical determination of the skin-effect is not possible. The solutions obtained for bar shapes, for which a straightforward mathematical solution is possible, indicate that the skin-effect is not affected by the actual width of the bar. This leads to the assumption that the "depth of penetration" is independent of the shape of the bar. The depth of penetration must be defined differently for the ratio of a-c to d-c resistance: r_{ac}/r_{dc}, and for the ratio of a-c to d-c inductance: l_{ac}/l_{dc}. Denoting the depth of penetration for r_{ac}/r_{dc} by h_{pr} and that for l_{ac}/l_{dc} by h_{px}, the assumption of independent depth of penetration means that for the bars of the same height but of different shapes, h_{pr} is the same and h_{px} is also the same. This is indicated in Fig. 1 for three bars of different shapes.

If the depths of penetration h_{pr} and h_{px} can be defined for a bar of a given shape, then the same result applies to bars of any other shape but of the same height. The definition of the depth of penetration is simple for the straight bar (Fig. 1*A*). For this bar

$$\frac{r_{ac}}{r_{dc}} = \varphi(\xi) = \frac{\sinh 2\xi + \sin 2\xi}{\cosh 2\xi - \cos 2\xi} \tag{1}$$

and

$$\frac{l_{ac}}{l_{dc}} = \psi(\xi) = \frac{3}{2\xi}\,\frac{\sinh 2\xi - \sin 2\xi}{\cosh 2\xi - \cos 2\xi} \tag{2}$$

$$\xi = 0.316\, h \sqrt{\frac{b_b}{b_s} \times \frac{f_1}{\rho}}\sqrt{s} \tag{3}$$

where

h = height of the bar.
b_b = width of the bar.
b_s = width of the slot.
f_1 = line frequency.
s = slip of the rotor with respect to the fundmental wave.
ρ = resistivity of bar material, $\mu\Omega$/cubic inch.

Thus, the depth of penetration with respect to the a-c resistance h_{pr} can be defined as

$$\frac{r_{ac}}{r_{dc}} = \varphi(\xi) = \frac{h}{h_{pr}} \tag{4}$$

that is

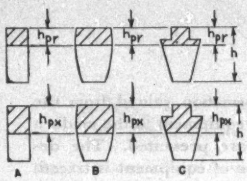
$$h_{pr} = \frac{h}{\varphi(\xi)} \tag{5}$$

and the depth of penetration with respect to the a-c inductance h_{px} can be defined as

$$\frac{l_{ac}}{l_{dc}} = \psi(\xi) = \frac{h_{px}/3b_s}{h/3b_s} = \frac{h_{px}}{h} \tag{6}$$

that is

$$h_{px} = h\psi(\xi) \tag{7}$$



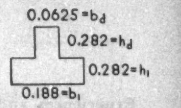


Fig. 1 (left). Explanation of the depth of penetration. Fig. 2 (above). Bar dimensions.

Applying these equations to a bar of a shape different from that of the straight bar, the total height h of the bar is to be used.

It is seen from Fig. 1 that, with the assumption of independent depth of penetration, the computation of r_{ac}/r_{dc} for any bar shape reduces to the determination of the ratio of two areas and the computation of l_{ac}/l_{dc} reduces to the determination of the ratio of two d-c inductances. The computation becomes simple since no Bessel or hyperbolic functions are involved as is the case with the solutions of bar shapes for which a straightforward mathematical treatment is possible, such as a tapered bar or a bar composed of a straight bar and tapered bar. Comparative calculations on bars for which a straightforward mathematical solution exists show that the depth of penetration method yields accurate results when the bar shape changes gradually. See Fig. 1*B*. However, the results of both computation methods do not agree entirely with each other when there is a sudden change in the slot (bar) width. See Fig. 1*C*. This is because the depth of penetration method does not take into account the sudden change of field intensity at the spot where the width of the slot changes suddenly. A correction factor of the magnitude of 0.95 to 0.92, by which h_{pr} and h_{px} must be multiplied, can be used in order to take into account the sudden change of the slot width.

For the bar shown in Fig. 2, the exact solution yields

$r_{ac}/r_{dc} = 2.01$; $x_{ac}/r_{dc} = 3.19$

The depth of penetration method yields

$r_{ac}/r_{dc} = 1.89$; $x_{ac}/r_{dc} = 3.1$

The difference between the two methods of calculation is only 6 per cent and 3 per cent respectively.

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Modern Electric Power Shovels

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Experiences and information gained from the application of electric equipment to the modern fully electric shovel are presented. The development of this type of equipment is traced, emphasizing the electrical problems solved. The required machine characteristics and application data are included.

THE FIRST CRUDE but practical steam locomotive was Stephenson's "Rocket" in 1829, while the first crude but practical steam shovel was the Otis invented in 1837. The steam shovel was a very successful machine for many years and played a very important part in the development of the United States.

The steam engine characteristic with high torque at low speeds and high speeds at low torques was very satisfactory for shovel duty. The electric-shovel engineers for many years attempted to duplicate the steam shovel characteristic for the electric drive. In fact, today one still hears the power shovel referred to as the "electric steam shovel."

As the electric shovel equipment improved and more was learned about the application of power to shovels, the steam shovel was gradually replaced until today there are no regularly manufactured steam shovels or draglines. The lives of the steam shovel and the steam locomotive seem to have started and ended about the same time and for just about the same reasons.

The Marion Power Shovel manufactured its first independent motor full-electric shovel in December 1908. Since that time there have been many changes and improvements made. More recent developments, such as the huge shovel shown in Fig. 1, will be touched upon. This 50–60-cubic-yard shovel is shown with an ordinary automobile and a 1-cubic-yard machine commonly used as a loading shovel by the average contractor.

Shovels and draglines are usually divided into three classes: the small machines, from $^3/_8$- to 3-cubic-yard; the medium size from 4- to 10-cubic-yard; and the large units from 12- to 60-cubic-yard capacity. The draglines are grouped very much in the same way except that the largest dragline today is only 35 cubic yards.

The standard crawler-mounted shovel is shown in Fig. 2. This type of machine is also made as a dragline. Draglines are available in two basic models; one with crawlers as just stated and the type known as walkers shown in Fig. 3. The walker-type propels by means of lifting cranks and does not require crawlers.

The Ward-Leonard electric shovels range in size from $2^1/_2$ cubic yards to the largest. The small machines, under $2^1/_2$ yards, are usually diesel-driven friction-operated.

The machinery deck layout of a 45-cubic-yard electric shovel, one of the largest in operation at the present time, is shown in Fig. 4. A close-up view of the motor-generator set used on this machine is provided by Fig. 5, while Fig. 6 is a view of the entire 45-cubic-yard machine.

Progress in design and construction of power shovels in the last 20 years has opened important new horizons in many industries. These modern excavating machines have made possible the development of dams for flood control and irrigation, hydraulic electric power, and other giant construction projects that otherwise would be impractical. The low-cost handling of large yardages has made possible the profitable mining of lower grade copper and iron ore deposits that were considered of little value only a few years ago.

The selling price of shovels and draglines ranges from $30,000 for a 1-cubic-yard machine to more than $2,500,000 for the largest, which indicates the exacting care required in the selection of the electric equipment that is the heart of the largest of these machines.

TYPES OF DRIVES FOR SHOVELS AND DRAGLINES

IN A GENERAL WAY, shovels and draglines are classified according to the type of power unit and control used, such as diesel- or gasoline-clutch type, diesel-clutch type with electric swing, diesel-electric, and full electric. The full-electric Ward-Leonard machine, taking power from the central station power lines, will be covered in more detail since the extremely large machines come in this category. The electric power is brought to the machine by a combination of overhead lines and cable, then through collector rings to the main revolving deck to run the a-c motor of the motor-generator set, or sets, to drive generators for independently powering the d-c motors for each main motion.

SHOVEL MOTIONS

A SHOVEL HAS THREE MAIN MOTIONS: the hoist motion that raises or lowers the dipper; the swing motion that rotates the cab; the crowd motion that gives the forward and backward movement of the dipper. On draglines, there is no crowd motion. The propel motion incidental to digging, moves the machine to or from the working face.

The hoist, crowd, and swing generators, including the

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exciter, are shown in Fig. 7. The motor-generator set is representative of those used in 7-cubic-yard shovels. One a-c motor drives the entire unit.

TYPES OF CONTROL

ELECTRICAL ENGINEERS will be especially interested in knowing a little about the development and refinements of the shovel control. The well-known d-c rheostat type of control was used on some of the earliest shovel applications. Acceleration or reversal of the series motors was obtained through heavy drum controllers and resistors that carried the full armature current of the motor. One generator was utilized to furnish power for all the motions performed.

The single generator had a drooping voltage characteristic, with the voltage set at a fixed value of approximately 320 to 330 volts. This generator used only a self-excited shunt field and weak differential series field.

The single generator had to be sufficiently large for the hoist motor which made it too big for the smaller crowd and swing motors. Furthermore, when more than one motor was connected to the generator at the same time, the generator output was divided between them. On later machines, to reduce the influence of one motion on the other, the control was modified slightly to increase the generator voltage and kilowatt output when a motor of any motion was started.

To better the generator response an improved rheostatic control was devised using a 3-field generator similar to the present-day Ward-Leonard generator. This generator had a separately excited field as well as a self-excited field.

An elementary diagram showing one motion of the standard Ward-Leonard control using the d-c 3-field generator is shown in Fig. 8. The three fields are the self-excited, separate excited, and differential series. The Ward-Leonard scheme of control incorporates a separate generator and motor or motors for each motion. A constant-voltage d-c exciter, either directly connected to the motor generator set or separately driven furnishes the excitation for all motions. The torque and speed of each motion is controlled by varying the field strength, hence the output of each generator by means of a controller manipulated by the operator.

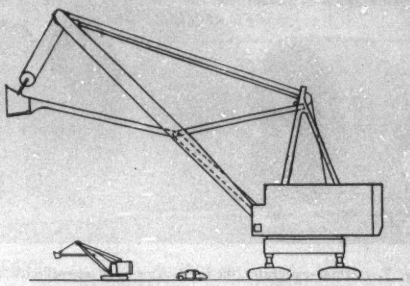


Fig. 1. Comparative size of 60-cubic-yard type-5760 shovel, a 1-cubic-yard shovel, and a standard automobile

Fig. 2. Medium-sized electric shovel, rated 7 cubic yards

Fig. 3. A large electric dragline of the walking type, rated 35 cubic yards, 200-foot boom

Fig. 4 (left). Machinery deck layout of a 45-cubic-yard electric shovel, showing three swing motors, two hoist motors, control cabinets, control exciters, and the two main motor-generator sets. Fig. 5 (center). Close-up view of 45-cubic-yard shovel motor-generator set. Large set driven by 1,250-hp 0.8-pf 3,810-volt synchronous motor. Small set driven by 250-hp 3,810-volt induction motor. Fig. 6 (right). Marion 45-cubic-yard shovel stripping coal in southern Ohio

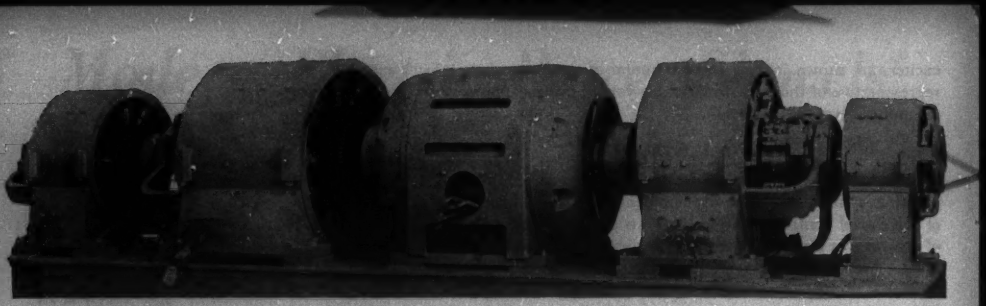


Fig. 7. Motor-generator set for 7-cubic-yard shovel with 450-hp induction motor, 225-kw hoist generator, 34/34-kw split-circuit swing generator, 40-kw crowd generator, and 10-kw direct-connected exciter

To increase the speed of response for the larger electric machines the Ward-Leonard control has been refined to include special high-speed field-forcing exciters or rotating control units. This type as furnished by the General Electric Company is called "Amplidyne Control" and by Westinghouse is called "Rototrol Control." Fig. 9 shows a very basic elementary diagram of this type of control for one motion. The use of individual control exciters permits forcing the generator fields to obtain faster response for acceleration and retardation and to reduce the tendency for the generator output to exceed the static curve, or, in other words, reduces overshooting.

The Ward-Leonard control has proved the most satisfactory for electric-shovel application. It gives high speed at light loads and low speeds with high torque at heavy loads. It permits regenerative braking to save power. Since each shovel motion has an entirely independent power unit it can be "tailor-made," so to speak, to obtain the most suitable speed and torque control for that motion. Limited speed and torque or power for each motion gives inherent overload protection without the use of any protective or current-limiting devices. The gears, shafts, bearings, etc., can be designed from predetermined loading to obtain the desired safety factors.

SHOVEL AND DRAGLINE MOTORS AND GENERATORS

THE SHOVEL OR DRAGLINE GENERATORS AND MOTORS are very rugged units designed for good commutation with high sudden overloads. It is standard practice to call on these units to commutate 200 to 225 per cent of their rated current. They are also designed to withstand 200 to 240 per cent of their rated voltage at rather high current, especially during regenerative braking. A typical speed—torque curve for one of the motors rated 250 hp, 420 rpm, 230 volts, with separately excited fields is shown in Fig. 10.

SHOVEL GENERATOR CHARACTERISTICS

SINCE THE WARD-LEONARD CONTROL SHOVEL GENERATOR and its characteristic curves influence the performance of the motor selected for it and, thus, the performance of the shovel motion driven by the motor, the shape of the characteristic curve has always been the subject of considerable study and change.

A typical static volt–ampere curve for a Ward-Leonard generator of the type used 10 to 15 years ago is shown by curve *A* of Fig. 11. The power curve that corresponds to curve *A* is shown by curve *B*. Curve *B* is simply the products of voltage and current of curve *A*. Point *G* is the short-circuit or stall current and point *H* is the maximum or no-load volts.

The shovel generator is differentially compound wound, which causes the voltage to decrease as the load (or current) increases, giving a drooping voltage characteristic. On the larger generators the rotating control exciters are used in conjunction with the differential series field to give the desired drooping characteristics. This type of characteristic definitely limits the maximum generator current and thus permits stalling the motor or, in effect, short-circuiting the generators, without flashovers and without damage to the mechanical parts of the machine. The desired maximum values of no-load voltage and stall current are adjusted by means of resistors and the operator may select intermediate values by movement of the master switch to vary the resistance.

The generator characteristic is basically the same for all motions; therefore, for purposes of this discussion, only the hoist will be considered, since it can be thought of as the most important motion.

The generator curve shown by *A*, although very satisfactory at first, did not give the characteristics desired for all types of digging as modern production demands increased. Consideration was given to reshaping the curve for improvements. Two such variations of curve *A* are shown in curves *C* and *D*, Fig. 11. Applying this curve to the hoist motion it can be seen curve *C* has a higher voltage at low currents which would give higher speeds at light loads or light digging. On the other hand, curve *D* has a higher voltage with high currents, giving higher speeds with heavy loads or heavy digging. The maximum power point of curve *C* is shown at point *K* and the maximum power point of curve *D* is at point *L*. The power obtained at points *K* and *L* is no higher than that of curve *A*. Reshaping the curve could be beneficial for certain conditions but is not an over-all improvement.

The trend toward larger lightweight dippers and the desire for higher speeds and more production in all types of digging made it imperative to use more power since, as in other types of equipment, the power must be increased if any over-all improvement in performance is to be realized. More horsepower was required. Before the power could

be increased, however, it was necessary to improve the designs of the generators and motors.

Early designed generators had highly inductive fields which were very slow to react to rapid changes in loads. When the dipper was suddenly stalled from a high speed, the hoist generator was subjected to high-current overshooting. With a normal stall current, for example of 1,600 amperes, the generator armature current would overshoot to approximately 2,400 to 2,500 amperes. Using a higher generator characteristic would greatly aggravate this condition so it was necessary to design generators and control to reduce this current overshooting.

Higher speeds meant that the generator voltage also had to be increased. The generators, and of course the motors had to be redesigned to withstand these higher voltages. All of these improvements in design were not accomplished easily, but required a great amount of research, tests, and everyday hard experience, which could make a complete story in itself.

These combined improvements made it possible to go to the high characteristics shown by curve *E* and corresponding power curve *F* which is representative of the generator curve on the modern full-electric Ward-Leonard shovel. Without radical changes in physical dimensions of given power units more power became available to provide very fast shovels and draglines for all classes of work.

Today there is still a great deal of time being spent on research and tests further to improve the generator and control in an attempt to reach the goal where the dynamic characteristic of the generator is the same as the static characteristic or curve. The ideal may never be attained, but preliminary results are encouraging.

SHOVEL MOTION CHARACTERISTICS

FROM THE GENERATOR AND MOTOR the next step in analyzing the hoist motion is the power curve at the dipper bail. With the generator characteristics Fig. 11, curve *E* imposed on the shunt-motor speed-torque curve, Fig. 10, and applying the mechanical advantage of gears, drum, and cables, a typical shovel bail pull–bail speed curve as indicated by Fig. 12, curve *A*, is developed.

The calculated points for plotting the bail pull–bail speed curve are given in Table I. The columns for this tabulation are obtained as follows:

Columns 1 and 2—Taken from the generator characteristic, curve *E*, Fig. 11.

Table I. Figures Calculated for Determining a Representative Bail Pull-Bail Speed Curve

1	2	3	4	5	6	7
Generator Voltage	Generator Current	Motor Speed, rpm at 230 Volts	at Generator Voltage	Motor Torque Foot-pounds	Bail Speed Feet Per Minute	Bail Pull Pounds
600	0	382	995	0	196	0
585	200	372	945	810	186	22,000
570	400	366	905	1,660	178	45,200
515	800	360	805	3,350	158	91,000
400	1,200	353	615	5,000	121	136,000
165	1,600	350	251	6,600	49	180,000
0	1,800	345	0	7,350	0	200,000

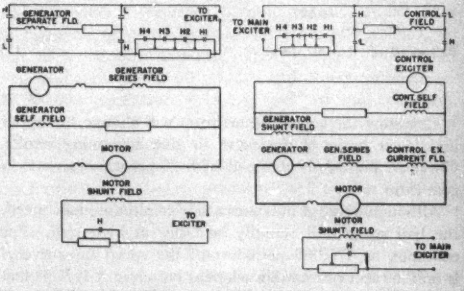


Fig. 8 (left). Simplified circuit diagram for one motion of an electric shovel with 3-field Ward-Leonard control. Fig. 9 (right). Simplified circuit diagram for one motion of an electric shovel with individual exciter, Ward-Leonard control

Column 3—Motor speed with rated armature volts taken from curve, Fig. 10.

Column 4—Motor speed with generator voltage imposed on the motor armature.

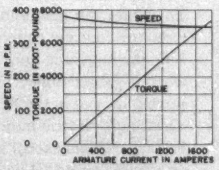
Column 5—Motor torque at normal excitation obtained from curve, Fig. 10.

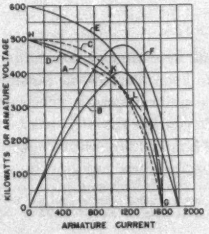
Column 6—Bail speed calculated for the speed points of column 4.

Column 7—Bail pull calculated for the motor torque points of column 5.

The method for calculating the constants and points of the curve are given in the following:

Gear ratio	58.6 to 1
Drum pitch diameter, inches	44.0
Mechanical efficiency, per cent	85.0
Line hitch, parts	1
Number of motors	1





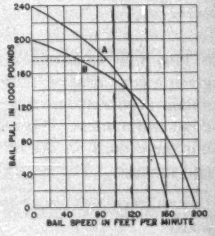


Fig. 10 (left). Speed and torque vs. armature current curves for a typical 250-hp 420-rpm 230-volt shovel or dragline motor. Fig. 11 (center). Shovel or dragline characteristics or load curves. Fig. 12 (right). Representative shovel hoist motion bail-pull vs. bail-speed curves

$$\text{Motor speed} = \frac{\text{speed at 230 volts} \times (\text{generator voltage} - *IR \text{ drop})}{230 - IR \text{ drop}} \quad (1)$$

$$C_t = \frac{\text{gear ratio} \times \text{efficiency} \times \text{hitch} \times \text{motors} \times 24}{\text{drum diameter}} \quad (2)$$

$$= \frac{58.6 \times 0.85 \times 1 \times 1 \times 24}{44.0} = 27.2$$

$$\text{Bail pull} = C_t \times \text{motor torque} \quad (3)$$

$$C_s = \frac{\pi \times \text{drum diameter}}{\text{gear ratio} \times \text{hitch} \times 12} \quad (4)$$

$$= \frac{\pi \times 44.0}{58.6 \times 1 \times 12} = 0.197$$

$$\text{Bail speed} = C_s \times \text{motor speed} \quad (5)$$

Changing the gear ratio or drum will change the upper and lower limits of the curve to give interesting results. Curve *B*, Fig. 12, is obtained with 20-per-cent increase in gear ratio.

Although curve *A* indicates a slower ultimate bail speed, the bail speed will actually be faster at high pull. For example, at 175,000 pounds pull the speed on curve *B* is only 60 feet per minute whereas on curve *A* it is 90 feet per minute. This means that should the maximum or stall bail pull be inadequate the hoist speed while digging can be stepped up by increasing the ratio. This is sometimes difficult to explain for as a rule, in other applications, increased speed is obtained with a lower gear ratio.

Although the change in gear ratio indicates a definite improvement under certain conditions, it should not be forgotten that such a change does not increase the maximum or peak power and, therefore, does not always result in increasing the over-all performance under all conditions. A high bail pull obtained by high gear ratio but without adequate peak power will not give the over-all performance required for a high-speed machine.

The selection of the proper gear ratio is as important as the selection of the motor and generator. If the gear ratio is too high it is impossible to use the available power properly. On the hoist, for example, an overly high gear ratio will give excessive bail pull that only results in undue mechanical damage. On the other hand, should the choice of gear ratio be too low, it will cause overheating of the motor and generator with consequent short life.

The speed torque curves for all motions of the shovel are calculated similarly to that shown for the hoist—the only difference being in the factors relating to the mechanical arrangements.

INERTIA

THE WK^2, or inertia, of the hoist and crowd motions is given a good deal of study to keep it as low as possible to obtain good response for the quick reversals necessary in these two motions. Wherever possible the WK^2 is kept low but there must always be a compromise with ruggedness and strength. The inertia load on these motions, however, is extremely low compared to the power required for digging.

When it comes to the swing motion, the inertia load is the main factor and becomes quite disturbing on the larger shovels and draglines. Machines of the largest sizes have a WK^2 of 8 or 9 billion pounds-feet^2. The tremendous inertia load must be accelerated to top speed and stopped in less than 90° arc of swing.

OPERATOR'S COMFORT

MORE AND MORE CONSIDERATION IS BEING GIVEN to the comfort of the operator on these modern electric machines. One man who may control the operation of a machine worth $1 or $2 million must work at peak efficiency to obtain the maximum production. A few lost minutes will cost the owner not a few cents, but many dollars.

VIBRATION AND DIRT

ONE OF THE MOST SERIOUS PROBLEMS before the shovel engineer, both electrical and mechanical, is vibration. The electrical engineer must take many precautions in the equipment and wiring to protect against failures. The wiring is securely laced to rods to give a rigid support that vibration cannot disturb. Insulated terminals, sleeves, insulated bushings, and extra-flexible wire are a few of the many items used to prevent failures from vibration.

In addition to these features, every piece of electric equipment must have built-in ruggedness—that is absolutely essential before it can be successfully used on shovels. From a shovel electrical engineer's viewpoint, there is no service as hard on electric equipment as power shovels.

If the equipment stands the vibration, then there is dust grease, or moisture that brings out a weakness. A good piece of electric equipment on shovels must be very good.

POWER CONSUMPTION

THE POWER CONSUMPTION PER UNIT OF MATERIAL HANDLED that is, per cubic yard or ton, is very low with Ward-Leonard control in spite of the fact that the dipper is frequently stalled. If we again refer to the generator characteristic the fact that the voltage is zero, at the stall point, practically no power is taken from the line because the generator is not producing kilowatts or power. (The only power at stall is that amount required to supply the losses.) The motor will exert the maximum torque because of the high stall current flowing through its armature.

Electric machines with other systems of shovel control, such as friction or magnetic clutches, must depend on slipping to obtain speed or torque changes. The greatest slippage occurs on a magnetic clutch-controlled shovel when the dipper is stalled (with the controller wide open). To obtain the maximum torque at stall requires that the motor driving the clutch use the corresponding high power from the incoming line. With the dipper stalled, no actual work is being done; therefore, the power must be dissipated in heat in the stalled or inner member of the clutch. The single-electric-motor friction-clutch machines have a similar problem except in this case the high heat loss at stall occurs in the rotor of the a-c motor.

It should be clearly understood that the Ward-Leonard

* Use total resistance of circuit including motor internal resistance but not generator internal resistance. (Not taken into consideration in curves calculated for this article.)

system has certain losses of its own. There is a loss in the main a-c motor driving the generator, in the generator itself, and in the d-c motor. These losses, however, are small in comparison with the high losses obtained when the peak power is wasted in heat.

POWER REQUIREMENTS FOR ELECTRIC SHOVELS

THE POWER DEMAND OF AN ELECTRIC SHOVEL fluctuates over a very wide range as the machine operates. When the machine is idling, that is, when all controllers are in neutral, practically no power is taken from the line. When the dipper enters the bank, a heavy surge of power is required from the line and while swinging and hoisting additional power is required. This wide fluctuation of the power supply is shown in Fig. 13 which is a typical a-c power chart for a large stripping shovel. The various parts of the operating cycle are indicated on the chart.

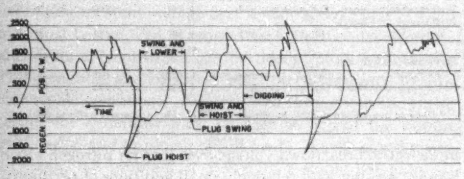


Fig.13. Kw chart of power input to a 35-cubic-yard stripping shovel

When lowering the dipper on full-electric Ward-Leonard-controlled shovels there is considerable regenerated power. The weight of the lowering dipper drives the hoist motors as generators which, in turn, furnish power to drive the hoist generators as motors. The hoist generators acting as motors drive the main a-c motor on the motor-generator set as an alternator to pump power back into the line.

Since the load fluctuates widely and the maximum peak load exists only for short periods, the motor driving the generators is not required to have a continuous rating equal to the maximum load. The a-c motor must have sufficient pull-out torque and pull-out horsepower to carry the momentary peak, but its continuous rating need only be equal to the rms load. Table II lists the power requirements and the ratings of the motor-generator set motors on four representative machines.

Table II. Power Requirements for Four Representative Shovels

Type	M-G Set Motor Rating Hp	Motor Average Output Hp	Motor Peak Output Hp
1	250	160	515
2	600	420	1,450
3	1,500	1,120	3,250
4	2,200	1,450	5,000

Although some of the smaller machines use lower power supply voltage, most large machines are 3-phase 60-cycle 4,160-volt powered. The extremely large machines of the future will operate on 7,200 volts power supply.

LARGEST STRIPPING SHOVEL

THE IMPORTANT DIMENSIONS of the world's largest stripping shovel, see Fig. 1, are:

	Feet
Boom length	150
Height of boom point	145
Height of crawlers	8
Length of crawlers	23
Size of cab deck	45 by 63
Maximum dumping height	97
Maximum dumping radius	145

The machine will make a complete digging cycle in approximately 50 seconds. It could dump the dipper load of material, weighing approximately 165,000 pounds, on top of a 10-story building. The machine will weigh approximately 5,200,000 pounds and cost approximately $2,500,000 excluding shipping and erecting expenses. It will be propelled by motors that can develop a peak of 2,500 hp intermittently.

The total horsepower rating of the motors driving the generator sets, excluding propel motors, will be 4,650 hp. The instantaneous peak power will be approximately 6,800 kw or approximately 9,150 hp.

It is estimated that the power costs for operating this machine will run approximately $10,000 to $11,000 per month. The power consumption required for a machine of this size would be the approximate equivalent of the power taken by 5,200 average homes or a city having a population of 15,000 to 20,000.

In the large-diameter hollow-center pin will be placed an automatic apartment-house-type elevator with controls suitable for stopping at three levels. This will carry operating personnel and visitors from the ground level to the main machinery deck or on up to the gantry, some seven stories high.

The application of the power units for swinging this giant machine presented a very interesting problem. To transmit the torque required to accelerate the cab to full speed and stop it in less than 90° arc of swing required tremendous gears and power. The largest vertical swing motors ever to be used on shovels had to be developed to make this possible.

CONCLUSION

SHOVELS AND DRAGLINES have become larger and faster to keep up with the modern demand for production at low cost. Only 25 years ago a 12-cubic-yard shovel was considered as the largest—nothing would be bigger. Today the 45-cubic-yard shovel is beginning to look small. When economic conditions justify larger machines, they will be constructed. It would be foolish to make any attempt to predict how much larger they may go, but they have increased fivefold in the last 25 years and no limit can be forecast for the next 25 years.

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2. Electric Equipment for Power Shovels and Draglines, **W. H. Schwedes.** AIEE *Transactions*, vol. 67, 1948, pp. 1498–1506.

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Electric Breakdown of Perfluorocarbon Vapors

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E. W. LINDSAY, ASSOCIATE MEMBER AIEE

THE GASEOUS AND LIQUID perfluorocarbons, which were developed during World War II, are among the more recent synthetic materials which show promise of finding applications in the electrical insulation field. These compounds came into being through the pioneer work done at the Johns Hopkins, Pennsylvania State, and Purdue Universities, and also by E. I. du Pont de Nemours and Company, Inc., and more recently by the Minnesota Mining and Manufacturing Company. The perfluorocarbons are completely fluorinated carbon compounds, showing quite different properties from their hydrocarbon counterparts.

Original work started in 1947 on perfluorocarbon vapors. Vapors of straight chain and cyclic compounds alone, and when mixed with nitrogen, showed surprisingly high dielectric breakdown values.

The compounds investigated are listed in Table I. It is very surprising to note that perfluorophenanthrane has four times the breakdown value of sulfur hexafluoride and ten times that of nitrogen. Perfluoromethylcyclohexane, a typical perfluorocarbon vapor, has a 60-cycle breakdown value under uniform field conditions and at 1-atmosphere pressure, equal to that of oil tested in the same cell.

The breakdown behavior of mixtures of a typical perfluorocarbon compound with nitrogen in a nonuniform field is illustrated in Fig. 1. Curves for positive and negative impulse and for 60-cycle voltages are shown. For this severe case of a divergent field, produced by a rod gap, it will be noted that the positive impulse values are somewhat lower than the 60-cycle crest values, whereas the reverse is true for the negative impulse values. Likewise, for pure compounds, significantly higher values of breakdown were found for negative impulse waves than for positive impulse waves under similar conditions.

A glance at Fig. 1 reveals that for mixtures, the increase in dielectric breakdown voltage over that for nitrogen alone is quite striking with relatively small additions of perfluoromethylcyclohexane. Similar behavior was also observed for the uniform field condition. This behavior of nitrogen-perfluorocarbon mixtures was a very surprising result. Since the breakdown values of mixtures with nitrogen were greater than for the pure vapor at the same pressure, the practical implication is that less perfluorocarbon is required for a given dielectric strength by use of mixtures.

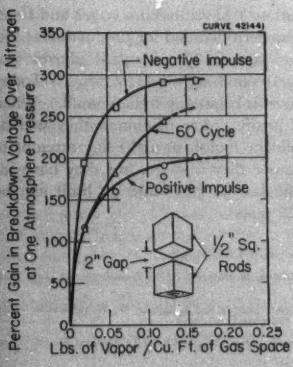

Fig. 1. Increase in breakdown voltage of nitrogen by adding small amounts of perfluoromethylcyclohexane vapor

Table I. Physical Properties and Breakdown Voltage of Compounds Investigated

Compound	Molecular Formula	Molecular Weight	Refractive Index at 20 C	Boiling Point, C	Breakdown*
Nitrogen	N_2	28		−196	1
Perfluoromethane	CF_4	88		−128	1.25
Perfluoropropane	C_3F_8	188		−38	2
Sulfur hexafluoride	SF_6	146		−63.8	2.5
Perfluoroheptane	C_7F_{16}	388	1.2618	82	5.5
Perfluorotriethylamine	NC_6F_{15}	371	1.262 at 25 C	71	6
Perfluoromethylcyclohexane	C_7F_{14}	350	1.2815	76	6
Perfluorotoluene	C_7F_8	236	1.3664	102	7
Perfluorodibutyl ether	$C_8F_{18}O$	454	1.26	100	7.5
Perfluorotri-n-butylamine	$NC_{12}F_{27}$	671	1.29 at 25 C	178	8
Perfluorodimethyl cyclohexane	C_8F_{16}	400	1.2896	101	8.5
Perfluorophenanthrane	$C_{14}F_{24}$	624	1.3315	205	10

* 60-cycle breakdown relative to nitrogen at 30 cm Hg in a nearly uniform field.

The breakdown values for both the pure perfluorocarbons and their mixtures with nitrogen were markedly reduced as the field became more nonuniform. This is also true of all electronegative gases, including sulfur hexafluoride.

In general, the higher molecular weight compounds have higher values of dielectric breakdown, but molecular structure may very strongly affect dielectric breakdown. For example, perfluorotoluene (Table I) although of relatively low molecular weight, has a high value of dielectric breakdown. The resonating system of double bonds possessed by this compound and the associated higher electronic polarizability seem to aid the absorption of energy from free electrons in the early stages of the breakdown process.

The perfluorocarbons, in addition to having high dielectric strength, have other desirable properties such as complete flameproofness, excellent thermal stability, and chemical inertness. These unusual properties of the higher molecular weight perfluorocarbons suggest that they should find applications in gas-filled sealed electric apparatus of various types.

Digest of paper 55-495, "Electric Breakdown of Perfluorocarbon Vapors and Their Mixtures With Nitrogen," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Scheduled for publication in AIEE *Communications and Electronics*, 1955.

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A New Power Supply for Railway Cars

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EXACTING SPECIFICATIONS for modern railway-car power supply, together with the necessity for extreme simplicity and reduced maintenance, rendered a new type of power supply desirable. This led to the development of a motor-generator-exciter system which, together with its associated control, represents a major advance in the art of railway-car power-supply design.

Such a system must be automatic, reliable, require minimum maintenance, and operate successfully over a wide range of temperatures and atmospheric conditions. It must provide satisfactory supply to the connected load at essentially constant voltage over a wide speed range. Control must be supplied to assure that a limit is placed on the maximum current which can be taken from the generator. The generator and regulator must be co-ordinated to provide stable operation. At any speed throughout the entire range, the generator must be able to accept the instant application and dumping of full load. As the speed range increases, the problem of designing a stable machine becomes more difficult. The system presented an added problem in that both the generator and exciter had to be designed as stable machines.

Different capacities of batteries used by various railroads require the axle-generator design to provide for nominal systems of 40, 80, and 140 volts, and to be capable of charging either nickel-alkaline or lead-acid batteries.

The new rotating equipment, consists of a 4-pole d-c shunt generator, a 6-pole exciter, and a 4-pole 3-phase 60-cycle 220-volt induction motor assembled on a common shaft. This machine is driven either from the car axle or from wayside power.

The control equipment includes an a-c panel mounting a line contactor, two overload relays, and an unloading relay; and a d-c panel mounting a line contactor, a voltage-regulating relay, a current-regulating relay, a reverse current relay, and a fuse or overload relay.

When the generator and exciter are not running, current is fed from the battery through rectifier *RT3* to the exciter field (Fig. 1). Rectifier *RT2* blocks this current so that it will not flow to the generator. As the set comes up to speed, the exciter builds up. Because the exciter field polarity is always the same, the exciter armature polarity will reverse with a reversal of rotation of the set. The generator field, connected directly across the exciter armature, will likewise reverse with set rotation. Since both rotation and field current are reversed, the generator polarity will remain the same, and an armature reversing switch is unnecessary.

As long as the generator voltage is higher than the battery voltage, the series coil of *RC* aids the shunt coil. When reverse current flows, the series coil bucks the shunt coil. This causes *RC* to drop out and open the generator contactor.

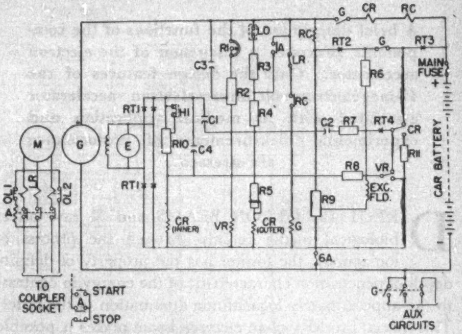

Fig. 1. Schematic connection diagram

The voltage-regulating relay *VR* has its contacts connected in the exciter-field circuit. When the generator voltage rises to the value to be regulated, *VR* starts to pick up. This reduces the exciter field current and, hence, the generator voltage. *VR* then drops back to its original position. This action continues and the relay vibrates in its normally closed contacts. As the generator speed increases, *VR* operates more in the open position than in the closed, and finally the contacts move to the outer side and vibrate against the normally open contact.

The current-regulating relay *CR* is similar in construction to the voltage-regulating relay. It has two bias coils and a coil connected in series with the generator output. When the line current reaches a predetermined value, *CR* picks up and reduces generator voltage. This drops out *VR*. *CR* then takes over the operation of the system, and vibrates against its stationary contacts to hold the proper amount of current.

Devices have been selected to include as many common parts as possible for each of the three voltage ranges. Proved circuit components have been largely employed. The amplification provided by the exciter permits applying the regulating relay contacts at a low volt-ampere level. Reducing the amount of control power lowers the temperature of the control locker and adds to the life of all equipment mounted in it.

Two simple relays, having a total of two double-throw contacts, replace the 20-contact multiple-finger voltage relay formerly used, and weigh only about one sixth as much. The armature reversing switch has been eliminated and, in addition, available speed ranges have been increased.

Digest of paper 55-205, "A New Power Supply for Railway Cars," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in AIEE *Applications and Industry*, July 1955, pp. 179–83.

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45-Mev Medical Linear Electron Accelerator

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A brief description of the functions of the components precedes a discussion of the electron accelerator. Only the design features of the 45-megelectron-volt linear electron accelerator associated with its medical application and experimental measurements of performance are stressed.

DIRECT ELECTRON BEAMS and X rays affect biological media mainly through the process of ionization; the former has the property of definite depth of penetration characteristic of the energy in contrast to the approximately logarithmic attenuation of the latter. This special property of an electron beam makes it possible to irradiate malignant lesions with little damage to underlying tissue, and its employment for medical use has been contemplated for many years.[1] Due to the technical difficulties of producing electrons of sufficiently high energy to give appreciable penetration, this possibility has only lately ripened into reality. The first therapeutic application of accelerated electrons was made in Germany with a 6-megelectron-volt (mev) Betatron beam extracted by a scattering foil and a deflecting electrode.[2] To date, the highest energy electrons employed for medical purposes are those extracted from a 22-mev Betatron with a magnetic shunt.[3] Since the extrapolated range of an electron beam in tissue, expressed in centimeters, is roughly one half of the energy of the electrons in mev,[4] electrons of higher energy will be required to reach disease in every part of the body.

Among the potential accelerators capable of producing electrons of the desired energy range, such as a linear electron accelerator, a Betatron, a Synchrotron, and a Microtron, the linear electron accelerator[5-10] appears especially attractive as a therapeutic instrument because its geometry is so suitable for an external beam, the ease of obtaining a high-beam current, and the noiseless operation. See Fig. 1.

Fig. 1. Control panel and zinc-bromide viewing window

GENERAL DESCRIPTION OF COMPONENTS

THE MAIN FEATURE OF A LINEAR ELECTRON ACCELERATOR, of the traveling-wave type, is a disk-loaded waveguide which supports an electromagnetic wave having a large axial electric field and a phase velocity of c, the velocity of light. This electromagnetic wave is excited by microwaves generated by a magnetron oscillator and amplified by a klystron amplifier. At the input end where the microwave energy is introduced, a beam of electrons is also injected into the accelerator tube by an electron gun. Some of these electrons will be immediately accelerated to a velocity close to c in a short distance and will ride the wave henceforth. Thus with a constant axial electric field pushing them forward, the electrons will gain energy approximately in a linear manner as they travel along at the expense of the energy of the field.

The simplified block diagram of Fig. 2 illustrates the operation scheme of the present accelerator and the relationship between various components. The main components can be classified as: (1) accelerator tube, through which both electromagnetic waves and electrons propagate; (2) microwave power source, for the excitation of desired electromagnetic fields in the accelerator tube; (3) main high-voltage supply, for furnishing pulsed cathode voltage to the klystron amplifier; (4) electron gun, to produce burst of electrons accelerated to about half of c; (5) trigger generators, for synchronization pulsers; (6) vacuum systems for evacuating klystron, accelerator tube, and magnet chamber; (7) protective interlocks, for personnel and equipment protection; (8) magnet system, for controlling

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The successful completion of the accelerator project reported here could have been achieved only through the joint co-operation of many who contributed to it in one way or another. The very existence of this project is due to the foresight and efforts of Dr. E. M. Uhlmann, director of Tumor Clinic, Michael Reese Hospital, who pioneered electron-beam therapy, recognized its significance for cancer treatment, and has labored for many years to assure the construction of an electron source suitable for medical application.

Several essential components of the accelerator: the accelerator tube subsections, the electron gun, the klystrons, and pulse transformers were procured from the Microwave Laboratory of Stanford University. With encouragement of its director, Dr. E. L. Ginzton, technical information and advice were generously supplied by the staff members of the above-mentioned Laboratory. The electron gun pulser design of Dr. P. A. Pearson, and the interlocks design of Dr. K. Mallory and his participation in assembling, deserve special mention. Acknowledgment is also made to Dr. W. C. Barber for many valuable discussions of problems associated with the machine in general.

Except for the components supplied by Stanford University, the accelerator and its associated equipment were manufactured with the co-operation of Helene Curtis Industries, Inc., under the direction of C. L. Lootens. He is also responsible for the design of the mechanical components of the entire installation.

In assembling, testing, trouble-shooting, and measurements, the helpful assistance of John Duplex, who worked under a grant of the Illinois Division of the American Cancer Society, was invaluable.

Finally, the writer wishes to thank the donors who supported this project. Their generosity made the construction of this accelerator possible.

the energy, dimension, and direction of the emerged electron beam; and (9) radiation-measuring devices, for tune-up indication and automatic control of exposures. A brief description of these main components is given.

Accelerator Tube. The accelerator tube is a disk-loaded waveguide with a tube of O.F.H.C. copper and disks of selenium copper fixed in position by shrinking. The total length of 10 feet is subdivided into five 2-foot sections. The dimensions are so chosen that the accelerator has a Q of 10,000, shunt impedance of 4.73×10^6 ohms per centimeter, phase velocity equal to c, group velocity of $c/100$ as a compromise between high field intensity and low attenuation, and the product of voltage-attenuation constant and total length equals 0.895, which approximately satisfies the condition of maximum acceleration,[11] at the operating wave-length of 10.5 cm.

The length L of the accelerator required to produce output electrons of certain energy can be obtained by simple fundamental considerations. Defining shunt impedance r as the ratio of the square of potential gradient to power dissipation per unit length, i.e.,

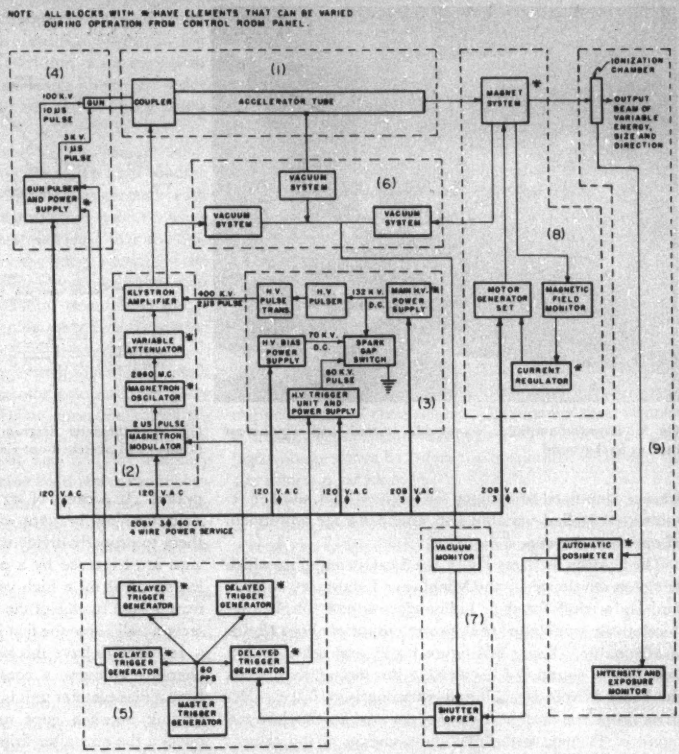


Fig. 2. Simplified diagram of the 45-mev medical linear electron

$$r = E_z^2/-\frac{dP}{dz} = E_z^2/2\alpha P \tag{1}$$

where $P = P_o e^{-2\alpha z}$ (2)

and E_z is the axial component of the accelerating electric field, P_o, the input microwave power at $z=0$, P, the attenuated power at z, α, the voltage attenuation constant expressed in nepers per meter due to copper loss, and z, the distance along the tube axis.

When electrons are accelerated by the field, the power loss per unit length is obviously given by the sum of copper loss and energy spent in accelerating these electrons,

$$-\frac{dP}{dz} = iE_z \cos\varphi + 2\alpha P \tag{3}$$

where i is the beam current and φ, the phase angle by which electrons ride ahead of the wave crest; here the assumption of a perfectly bunched beam has been made. Substituting P from equation 1 into equation 3, one obtains:

$$-\frac{dE_z}{dz} = i\alpha r \cos\varphi + \alpha E_z \tag{4}$$

The foregoing equation can be readily integrated with initial condition: $E_z^2 = 2\alpha r P_o$, $z = 0$,

$$E_z = (ir\cos\varphi + \sqrt{2\alpha r P_o})e^{-\alpha z} - ir\cos\varphi \tag{5}$$

To find the energy gain, V, of the electrons after being accelerated for a distance L, one has:

$$V = \int_0^L E_z \cos\varphi dz = \left[\sqrt{2\alpha r P_o}\cos\varphi\left(\frac{1-e^{-\alpha L}}{\alpha L}\right) - ir\cos^2\varphi\left(1-\frac{1-e^{-\alpha L}}{\alpha L}\right)\right] \cdot L \tag{6}$$

Knowing the input power, product of αL, shunt impedance, and stable phase angle of electron bunch, the final energy of an electron beam for an accelerator of length L can be determined from the foregoing equation.

Microwave Power Source. To start with a microwave of about 10.5-cm wavelength is generated by a Raytheon *Rk 5586* tunable Magnetron with a magnetic field of 1,900 gausses, and modulated by a 20-kv 2-microsecond (μsec) pulse modulator. The frequency of oscillation of the Magnetron is remotely tuned from the control panel and its output power is fed to the klystron input cavity through a

Fig. 3. Klystron amplifier, waveguide systems with equipment rack as background

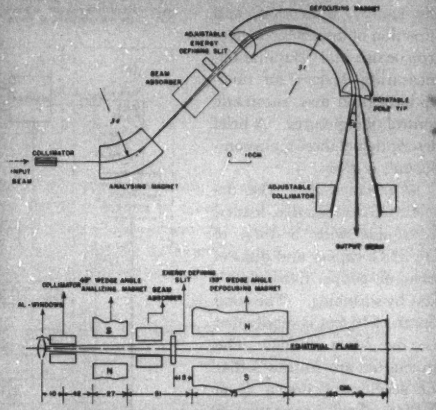


Fig. 4. Schematic diagram of the magnet system: Side view (above) and stretched-out view (below)

transite slab fixed attenuator for isolation and another remotely controlled variable slab attenuator for adjustment of optimum driving.

The klystron used, see Fig. 3, is a 3-cavity amplifier which has been developed by the Microwave Laboratory of Stanford University[12] for their billion-electron-volt accelerator. A relatively troublefree peak power output of about 18 mw is obtainable. Using this figure for P_o and other known numbers in equation 6, neglecting the second term when the beam current is small and assuming $\varphi = 0$, i.e., electrons riding the crest of the wave, one obtains the designed figure of 45 mev as the maximum energy of the present accelerator.

Main High-Voltage Supply. The operation of the klystron requires a pulsed high-voltage supply of 400 kv maximum voltage, 2-μsec duration and 60 pulses per second (pps). The system used consists of a 3-phase full-wave rectifier circuit with six Macklett *ML/200* rectifier tubes. The d-c output of the circuit is continually adjustable up to 70 kv by three remotely controlled powerstats in synchronism at the primary of the high-voltage transformer. The output current of the rectifier system charges the pulse-forming network through a choke of 700 henries in resonance with the total capacity of the pulser, 0.029 microfarad (μf), and thus the voltage across the pulser is almost doubled.

The pulse-forming network includes ten 0.0029-μf oil-filled capacitors designed to operate at 132 kv 1,500 amperes pulse current, and inductances of three turns of 3/8-inch copper tubing, 13-inch diameter between capacitors. This network has a characteristic impedance of 42.5 ohms and gives pulses of 2-μsec duration. The end of this pulse line is connected to the primary of a klystron pulse transformer which is immersed in "Special Marcol" transil oil in a tank together with the cathode part of the klystron. The pulse transformer has a step-up ratio of 6:1, and for the matched condition, delivers a negative pulse of 400 kv maximum to the klystron cathode.

A spark-gap switch is employed for discharging the pulser. It consists of six 3-inch-diameter hollow copper balls, forming five gaps with resistors and capacitors across them to properly divide the voltage under pulsing. These gaps are triggered by a positive trigger pulse of about 60 kv, supplied by a high-voltage trigger amplifier which in turn is fired by one of the delayed trigger generators at the second ball while the first is grounded.

In order to have this switch work over a wide range of charging voltages, a constant 70-kv positive-bias voltage from a bias-rectifier unit is required at the third ball and the spacing between gaps must be properly adjusted. To quench the arcs after firing, an air jet is provided at each gap, and the whole assembly is enclosed in a box which is acoustically shielded to reduce noise.

Electron Gun. The electron gun used consists of a bombarded cathode with focusing ring, grid, and anode in front of it. The anode is grounded and the remaining electrodes are pulsed to −100 kv with 10 μsec pulse at 60 pps. With this pulse alone, no electrons will be injected because the grid completely shields the field from the cathode. Then another pulse of 3.5-kv 1-μsec duration is applied between grid and cathode during which time a focused electron beam will be introduced into the accelerator tube. The triggering of this 1-μsec pulse should start at the end of the filling time and this pulse should be adjusted to lie within the flat portion of the 100-kv pulse.

Trigger Generators. The triggering pulses of the magnetron-modulator klystron spark-gap switch and electron gun are derived from four separate delayed-trigger generators which are driven by one master trigger generator. The proper synchronization of events is achieved by adjusting respective delays.

Vacuum Systems. Three separate vacuum systems are used in the present accelerator: for the klystron, the accelerator tube and its associated waveguide, and for the magnet system. The klystron vacuum system consists of a mechanical fore-pump of 100 liters per minute free-air

capacity, a 4-inch 3-stage oil diffusion pump, and a liquid nitrogen cold trap. The pressure measured with an ion gauge near the cold trap is about 10^{-7} mm of mercury with 200-watt idle heater power and increases about one order when full heater power of 800-watt and 400-kv anode pulses are applied.

The accelerator and its associated waveguide are separated from the klystron vacuum system with a glass window which allows the microwave energy to pass through with but little loss and reflection. Their vacuum system consists of the same items as the klystron system except that an additional mechanical pump is used for the guard vacuum of the accelerator tube. There is a 1/2-inch Veeco valve between guard vacuum and main vacuum that permits the use of both mechanical pumps for roughing whenever the system has been "let-down."

The vacuum of the accelerator system, measured at half way between cold trap and accelerator input end, is slightly below 5×10^{-6} mm mercury during operation. The accelerator tube is pumped at both ends through the rectangular waveguide at the input end and an auxiliary cylindrical tube of about the same conductance to molecular flow at the output end. Even so, because the low conductance of the disk-loaded structure, the vacuum at the middle portion of the accelerator tube probably will not be better than 10^{-5} mm mercury.

The magnet system, consisting of two wedge-shaped magnets, one for analyzing and the other for defocusing, is capable of rotating 45° to each side of the vertical. To avoid the use of a rotating vacuum joint, its vacuum chamber is evacuated by a separate system composed of a mechanical fore-pump and diffusion pump similar to the other two systems but without a liquid-nitrogen cold trap. The pressure near the output end of the chamber, where pumps are located, is 10^{-6} mm mercury while that at the input end is five times higher. Because the only consideration of vacuum in the magnet chamber is the scattering of electrons, the requirement is less stringent than for the accelerator system where the field breakdown consideration sets a higher standard.

Protective Interlocks. Since there are dangerous high voltages, radiation hazards, and expensive equipment associated with the operation of the accelerator, a rather extensive protective interlocking system has been incorporated. For personnel protection, besides the door switches, the treatment room door is normally locked and can be unlocked only with one of two keys taken from a master keyboard at the control panel. The removal of one shuts off the high voltage of the gun and the other, that of the magnetron modulator. In either case, radiation hazards from the accelerator are eliminated.

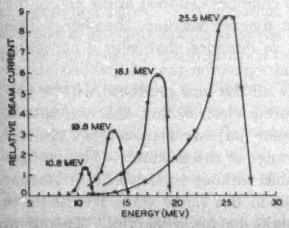
Besides, three more keys, for the cage doors of the high-voltage rectifier, and the main pulser, and for cover of the klystron oil tank respectively are interlocked in such a way that the removal of any one of them will make the application of high voltage impossible and thus safeguard the personnel servicing these regions.

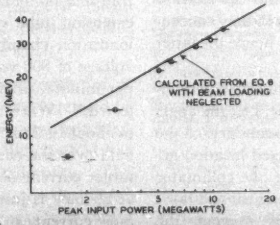
Furthermore, warning lights and push-button switches are installed at several locations inside the treatment and accelerator rooms. The former are used to indicate proper stage of operation of the accelerator, while the latter are for the protection of personnel who might accidentally be trapped in one of these rooms. After one of these switches is pressed, the operator will not be able to turn on the main high voltage unless he enters the accelerator room and resets a certain switch.

Once the treatment room door is locked and all keys are in position, a chime will sound for 10 seconds before high voltage can be applied. This audible signal serves as further warning to anyone who happens to stay in dangerous areas.

For equipment protection, interlocks are provided for klystron, diffusion pumps, ion gauges, electron gun, accelerator tube, and spark gaps, so that these components will not be damaged by abnormal operation conditions. Vacuum failure is indicated by a buzzer alarm during working hours. During off hours, a remote alarm box at the telephone exchange switchboard will sound so that the operator can inform a staff member of the accident.

Magnet System. The output electron beam from the accelerator is not immediately suitable for therapeutic applications. First, the beam generally has an energy spectrum that is broad enough to make it difficult for dosage planning and monitoring because of the dependence of range, scattering, and specific ionization on energy. Although this difficulty can be reduced by employing prebunching to improve the spectrum, there is still the problem of energy control. It is true that the peak energy depends on the output power of the klystron, and the adjust-





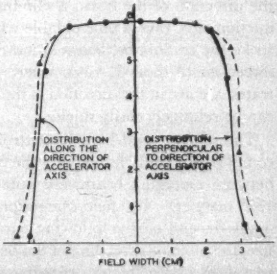

DISTRIBUTION ALONG THE DIRECTION OF ACCELERATOR AXIS
DISTRIBUTION PERPENDICULAR TO DIRECTION OF ACCELERATOR AXIS
FIELD WIDTH (CM)

Fig. 5 (left). Typical energy spectra of output electrons measured with constant gun emission current and 1 per cent energy resolution for various input-power levels. Fig. 6 (center). Variation of output electron energy with input microwave power. Fig. 7 (right) A typical current density distribution over target area with 30 mev beam and 1 per cent energy resolution

ment of main high voltage, which in turn dictates the klystron output and can be used to advantage for controlling the energy of the beam, but the critical dependence of the output beam energy on tuning and slow drifting of optimum tuning due to various factors almost certainly excluded this approach to energy control.

For the present accelerator, two electromagnets, as shown in Fig. 4, are used for controlling the beam energy as well as beam size and direction. The first one, located immediately at the output end of the accelerator and the input aluminum-foiled window of its vacuum chamber which are separated from the accelerator output window by about 1/2-inch air gap, has a 45° wedge angle which bends the electrons of desired energy upwards 45° from the horizontal and functions as energy selector. Electrons of other than desired energy will mostly be stopped by the graphite beam absorber in front of the lead energy defining slit. The wanted electrons, after passing through the slit whose opening determines the energy resolution, will then enter the second magnet of 135° wedge angle perpendicular to its entrance-pole piece boundary and finally emerge vertically downward. The magnet system as a whole, can be rotated about the axis of the accelerator tube to 45° to each side of the vertical in order to direct the beam conveniently. The patients in the target plane are 5 feet from the 135° exit pole tip. Prior to entering the first magnet, the size of the output beam from the accelerator is limited by a graphite collimator of 1 cm² square opening.

To accommodate lesions of various sizes, it is necessary that both dimensions of the rectangular beam produced at the target plane are controllable over considerable range and adjustable in a simple manner. Furthermore, the beam current density over this field must be uniform. One way of achieving these objectives is by first broadening the beam by scattering and then using various fixed sizes of cones of lucite or similar materials to define the desired field. Since the effective atomic number of these materials is low, a proportionally small amount of X rays will be produced in the direction of the electrons. This method has been adopted by Betatron workers.[8]

With the intention of producing a "cleaner" beam, a somewhat different scheme has been used for the present design. The magnet system is designed in such a manner that the electrons will encounter no obstacles in their downward travel and thus the possibility of X ray generated in the direction of the beam is eliminated. To be sure, production of X rays is unavoidable when the unused electrons strike the collimator, beam absorber, etc., but the forward directions of these X rays, where most radiation concentrates, are not in the direction of the target; hence the latter can be relatively easily shielded.

The scheme used here to control field dimensions is accomplished mainly by varying the exit angle, i.e., the angle between emerging beam and pole piece boundary of the 135° magnet. The field dimensions at a fixed location actually depend on the following parameters: the collimator size, the angular spreading of the beam in vertical and horizontal direction before entering the 135° magnet, the energy defining slit width or energy spreading, and the beam entrance and exit angle.[13] However, for the present design, the parameters are so adjusted that a linear dimension of from 1 to 12 cm along either direction of the field can be obtained by adjusting the exit angle alone, and for certain particular combinations of dimensions, with the help of also varying the entrance angle. The energy resolution at the field is also adjustable with a maximum of 5 per cent spreading.

In practice, it was found that the scattered electrons produced at the slit walls make it rather difficult to have sharp boundaries of the field at the two sides that are parallel to the gap field direction. Therefore, another adjustable slit located below the exit pole tip of 135° magnet made of graphite is used to eliminate the scattered electrons. This, of course, will introduce a small amount of X-ray background. The emerging beam is slightly divergent, with an angle from 1 to 3°, depending on settings of the exit-pole tip angle and energy-defining slit.

For the energy as well as location stability of the field, it is necessary to regulate the currents through the magnet coils which are supplied by two d-c generators, one 6 volts and the other 12 volts, driven by one single a-c induction motor. Current regulators of the Berkeley version,[14] which give a stability of better than 0.1 per cent, are used to regulate the field currents of the generators. The actual field intensity of each magnet is read with a synchronous-motor-driven pickup coil inserted in the respective field. The coil is wound as in a continuous-wound d-c generator, and silver commutator and brushes are used to reduce the effect of thermal emf. Its output voltage, which is proportional to the magnetic field intensity, is measured with a potentiometer so that little current actually flows through the coil.

The energy of the electron beam is determined by the output voltage of the pickup coil of the 45° wedgo-angle analyzing magnet and this voltage was calibrated against known thresholds of electro-disintegration. Foils of copper and polystyrene (carbon) were used which have thresholds at 10.9 and 18.7 mev, respectively.

The present arrangement of energy monitoring, unlike the method of measuring the magnet current, is free from the effect of hysteresis and hence any desired beam energy can be set directly without going to the trouble of demagnetization. This is very helpful for therapeutic application where quick change of energy to suit individual cases is required.

Radiation-Measuring Devices. The output current of the accelerator that is delivered to the target is measured with a transmission ionization chamber clamped at the end of the extension tube of the magnet vacuum chamber. This ionization chamber is so designed that with a collection voltage of 800 volt, and ionization rate of 1,500 roentgens per minute, practically all the ions produced will be collected.[15] When measuring electron flux, this corresponds to about 10^{-9} microampere (μa) target current for a 100-cm² field over the energy range of the machine. The average target current obtainable without excessive beam loading at 35 mev is just about in this range while several times more current can be obtained at lower energies. Therefore, multiplying this target current by the ratio of total area under the energy spectrum to the area for 2-per-cent resolu-

tion near the peak of the curve, which is about 10, and by a factor of 2 to take care of the beam lost at the collimator, one finds the maximum average output current of the accelerator itself to be near 1μa.

In order to deliver a predetermined dose of electrons to the target, an automatic dosimeter is adopted. It is mainly a negative feedback electrometer tube circuit, with grid voltage proportional to the integrated ion current from the ionization chamber; the voltage developed across a resistance in the plate circuit, balanced by an adjustable reference voltage connected in opposite sense, is used as input signal to the shutter-offer circuit. When the desired dose has been delivered, as set by the reference voltage which can be read with a voltmeter, a signal of about 1 volt is sent to the shutter-offer which in turn stops the triggering of the klystron high voltage and thus completes the operation. The accelerator will remain inoperative unless a new desired dose and the shutter-offer have been reset.

OPERATION CHARACTERISTICS

Energy Spectra. The energy spectra as shown in Fig. 5 were obtained with target current of 1-per-cent energy resolution collected by the Faraday cage plotted against the magnetic field intensity of the analyzing magnet which in turn has been calibrated in terms of energy in megelectron volts. The spectra of four different maximum beam energies corresponding to increasing higher input power levels are included in order to illustrate the effect that for fixed-gun injection current, higher beam current is obtained for higher input power as a consequence of the fact that a greater fraction of injected electrons will be found to the wave for a higher microwave field.

Effect of Microwave Power on Maximum Energy. As demonstrated by equation 6, the maximum output energy of the accelerator is proportional to the square root of microwave power input to the accelerator, if the beam current is of such small value that the effect of beam loading can be neglected. The experimental result of the variation of maximum output energy, V, against the output power of the klystron is shown in Fig. 6. Except for small errors introduced by the reflections at several junctions, this power can be taken approximately as the input power of the accelerator. Due to various reasons, the klystron used has not been able to produce optimum output power of 18 mw. Therefore, only energy slightly over 35 mev has been obtained from the machine. However, by extrapolation, it can readily be observed that V at 18 megawatts input power is close to the designed figure The apparent discrepancy at lower energies is probably due to larger errors of the thermister-bridge power-meter readings when they are small.

Current Distribution at Target. The blackening of a photographic film exposed to an electron beam is related to the current density and is independent of energy, provided the energy is above about 1 mev.[18] This film method has been used for the measurement of field uniformity. The film, after being exposed at the target plane, was developed under controlled conditions and its density was read with a densitometer. The densitometer reading was calibrated in terms of current density and fog density was corrected.

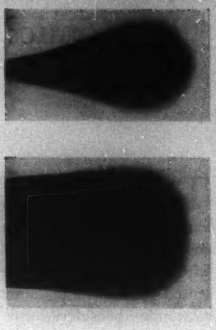


Fig. 8. Typical ionization pattern obtained in body-equivalent masonite phantom showing the definite range of electron beams of 30 mev (1% resolution) and the dependence of lateral ionization on field size (1.5 × 1.5 cm and 9.0 × 9.0 cm., respectively)

The result for a typical 36-cm² square field is given in Fig. 7.

Ionization-Depth Distribution. The ionization-depth distribution of an electron beam in a certain medium is the combined result of the effects of multiple scattering, straggling, energy dependence of specific ionization, radiative loss, and geometry that defies simple theoretical calculation. Yet this information is of importance for medical applications.

In Fig. 8, a typical ionization distribution at 30 mev for two different field sizes were obtained with photographic films embedded in a tissue-equivalent masonite phantom, with the plane of the film in the direction of the beam. The characteristic feature of a definite range of the electron beam is clearly illustrated. Also, it is to be noted that the lateral distribution of ionization varies strongly with beam size. This phenomenon indicates interesting possibilities for medical applications.

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Economics of Higher Voltages in Commercial Areas

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THE INCREASING USE of higher secondary voltages in commercial areas continues to focus attention on various secondary voltages that are feasible from both engineering and economic standpoints. Previous studies[1,2] with which the authors were associated have already presented considerable material on the engineering and economic considerations in secondary-network system planning and design.

This recent undertaking deals with the great majority of secondary networks designed on the basis of "first contingency." Such a design results in a system capable of supplying the load in the event of the loss of one primary feeder and its associated network units.

Results of these most recent studies are divided into five major categories:

1. Effect of secondary voltage upon secondary-network costs for uniformly distributed load, with densities ranging from 25,000 to 200,000 kva per square mile.
2. Economics of higher primary-feeder voltages, showing comparative costs of 4-kv, 13-kv, and 34-kv primary voltages serving networks operating at either 120/208 or 265/460 volts secondary voltage.
3. Spot-network (multiple network–transformer installation) costs for different network–transformer ratings at 120/208 and 265/460 volts secondary voltage.
4. Mutual support of adjacent spot networks, and the effect of secondary voltage upon ability to transfer load economically through secondary ties between spot networks.
5. Economic comparison of the conventional network system, and the spot-network–radial system for either 120/208 or 265/460 volts.

The conventional network system, in which single network–transformer units are added at many points on the low-voltage grid, has been in use for about 30 years. The spot-network–radial system is new, however, and involves the use of relatively larger-size network units installed in multiple-unit vaults, with multiple conductor per phase, and

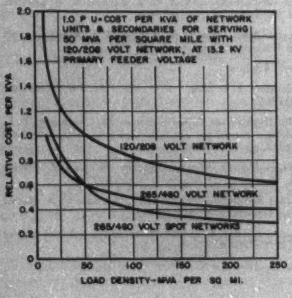
P U-COST PER KVA OF NETWORK UNITS & SECONDARIES FOR SERVING 50 MVA PER SQUARE MILE WITH 120/208 VOLT NETWORK, AT 13.2 KV PRIMARY FEEDER VOLTAGE
120/208 VOLT NETWORK
265/460 VOLT NETWORK
265/460 VOLT SPOT NETWORKS
RELATIVE COST PER KVA
LOAD DENSITY-MVA PER SQ MI.

Fig. 1. Effect of secondary voltage on the cost of general and spot-network–radial systems. Primary-feeder costs are not included

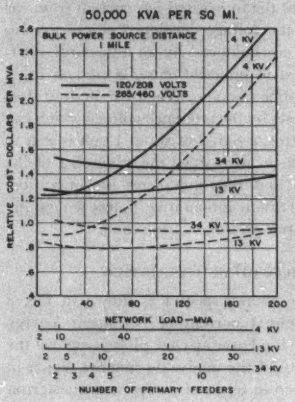

Fig. 2. Effect on network-system cost of load density, network load, primary-feeder voltage, and secondary voltage for a bulk-power source distance of 1 mile from network periphery. 1.0 per unit cost is the same as that of Fig. 1

265/460-volt radial secondaries radiating from such vaults to reach from two to three times as far to serve load as can be done at the conventional voltage of 120/208 volts.

In Fig. 1, the results of the comparative-cost study for three different systems are shown, including the installed cost of network units and secondaries. These results based on first-contingency design, show savings for higher secondary-voltage systems comparable to those obtained in earlier studies based on second-contingency design.

The inclusion of primary-supply cost in the comparison adds two parameters to return cost analysis: the total load on the network, and the distance of the network from the bulk-power source where the primary feeders originate. Fig. 2, effect on system cost of primary-feeder voltage, secondary voltage, and network size are shown for networks located 1 mile from the bulk-power source. Other results show that a primary-feeder voltage of 13 kv is generally economical to serve a network area having either 208 or 460 volts secondary voltage, and that the combination of 460 volts secondary voltage, and a primary-feeder voltage above 13 kv becomes increasingly favorable as load density, network load, and distance of the bulk-power source from the periphery as the network become greater.

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Digest of paper 55-481, "Economics of Higher Primary and Secondary Voltages for Commercial Areas," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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A New Insulating Material for Traction Motors

R. W. FINHOLT

THE STANDARDS FOR TRACTION MOTORS list them as class *B* (1943 AIEE Standard No. *11*), which provides that peak value by resistance shall not exceed 160 C for the armature and 170 C for the fields. Modern diesel-electric locomotive traction motors often exceed these limits by 20 to 30 C. Coupled with this are severe vibration conditions, dust, water, varying humidity, highly variable maintenance, and shock.

In the search for better materials, tests have been run on a high-temperature material with such excellent properties that the General Electric Company is adopting it widely for use on traction motors. This new material is known as mica mat. The form found most useful in traction-motor insulation is impregnated with silicone resin, and used both as wrappers on armature coils and as tape on field coils.

Preliminary laboratory tests included humidity and pressure tests, heat aging, various electrical tests, tensile strength, flexural strength, bursting strength, flexing over a sharp-edged mandrel, resin content, thickness, density, and exposure to arcing and corona.

The first tests were on flat sheet, heat-aged at 250 C for 5 days. Mica-mat sheets impregnated with alkyd resin, with silicone, and with several polyesters were tested. At the end of a week only the silicone-impregnated sheet retained its original properties.

In a long-term aging test, lengths of copper wire wrapped with $3^1/_4$ wraps of mica mat were put in an air oven at 250 C. Even after 14 months there was no significant change in dielectric properties. Several samples were put in a furnace and held at 600 C for $3^1/_2$ hours. At the end of this time the copper wire was badly oxidized and a comparison sample of silicone-impregnated asbestos was falling apart. The mica-mat samples were in good condition, mechanically intact, and still had practically all of their original dielectric strength.

Tests at humidities from 42 to 90 per cent showed that both silicone-treated mica mat and untreated mica mat had an increase in dielectric strength, however, in several other tests a loss in strength was found when there was condensation of water within the mica-mat sheet. Comparable tests run with silicone-pasted (12-per-cent silicone) mica tape on a glass backing gave results almost exactly like mica mat with about 12-per-cent silicone. Heat aging the mica mat at 250 C before humidity tests gave results comparable with nonaged samples. Test bars run at 600 C for $3^1/_2$ hours and put in a 100-per-cent humidity chamber at 50 C showed a loss of 6 per cent in dielectric strength after 24 hours. Untreated mica mat is very water sensitive, but the 600 C aged material did not break up in water and retained most of its original nonwetting characteristics. This showed that mica mat impregnated with silicone would retain its water resistance even after prolonged heating.

The combined effect of heat and pressure on silicone-treated mica mat was evaluated. A check proved that increasing the concentration of silicone resin lowered the crush resistance. The results of this test show that below about 7-per-cent silicone no failure takes place, even at 20,000 pounds per square inch (psi); but with increasing amounts of silicone, gradual reduction in the crush resistance takes place.

The general conclusion from the pressure tests was that mica mat was satisfactory in this respect for application in traction motors if the silicone was kept below 15 per cent and the cure was sufficient. Also catalysts were necessary for the cure, and if extreme resistance to pressure was needed the resin content should be kept below 7 per cent.

Life tests, carried out on both field and armature coils, were both involved and lengthy. In one typical case a *GE-733* traction motor was used with armature coils insulated with $3^1/_4$ wrappings of glass-backed silicone-sheet material. This motor armature was run in a torsional shake test stand for 250 hours at 200 C and for 90 hours cycling from 30 to 200 C. The amplitude of vibration was approximately 0.021 inch at 27 *g*. At the end of this time the insulation still appeared to be in good condition, but the binding wire was loose and the wedges were charred and loose. The armature was then heated to 250 C and the amplitude of vibration doubled. After 200 hours the wires broke. On conventional coils with varnished-asbestos-turn insulation and paper-backed silicone-pasted mica tape as ground insulation, the ordinary varnish was completely disintegrated leaving the asbestos as a white fluffy mass. Coils with mica-mat ground insulation had nearly original dielectric strength. The conventional mica-tape coils were also satisfactory except at points where the armature had come to extreme heat. Here the binder had decomposed, allowing the mica flakes to slip, and coils failed.

After these life tests, sample motors were put in all types of traction service ranging from trolley coaches to main-line locomotives; some motors are going into their fourth year of service. It is evident that mica mat was not simply an adequate substitute for mica tape on armature coils, but rather a superior insulating material; it was lower in cost, gave more uniformly shaped coils, would stand more heat and vibration, and was somewhat easier to use in the factory. On the other hand, field tests showed that mica mat was not a universal substitute for mica tape. At the present time, it does not seem suitable for taping armature conductors, although it makes excellent wrappers for ground insulation on armature coils. Neither does it seem suitable for field coils where high pressures are exerted.

Digest of paper 55-204, "Thermal Stability of a New Insulating Material Used in Traction Motors," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in AIEE *Applications and Industry*, March 1955, pp. 37–41.

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Research in Signal Corps Teletypewriter and Switching Equipments

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MEMBER AIEE

Past and present research and development in teletypewriter and teletypewriter switching equipments conducted by and for the U. S. Army Signal Corps is described.

TELETYPEWRITER EQUIPMENTS and switching systems are considered the work horse of the U. S. Army since they provide practically all of the record communications of that service. Teletypewriter-equipment development is divided into two major fields: terminal equipment such as printers, reperforators, tape transmitters, etc.; and tape relay or switching systems. Each field is further subdivided into equipment designed for tactical or field use, and "fixed-plant" equipment for operation in fixed or semifixed installations in higher echelons of the Army communications system.

The need for highly portable, ruggedized lightweight tactical teletypewriter equipment, designed specifically for military use, was recognized by the U. S. Army Signal Corps Engineering Laboratories as early as 1926. Early Laboratories activities were directed toward internal development of equipment designed to function satisfactorily with field power units, but indications of possible involvement in World War II dictated de-emphasis of internal development and the decision to employ commercial equipment then available. Initiation of development which culminated in the new line of tactical and fixed-plant equipment was authorized in 1944, when reactions of the using arms, responsible Signal officers, and theater observers all indicated immediate need for such equipment to replace the modified, but inadequate, commercial gear employed by the U. S. Army for tactical use.

The first tactical equipment developed in the program was teletypewriter set *AN/PGC-1*, designed and produced by Kleinschmidt Laboratories. A second production source was the National Cash Register Company. This set, utilized in all tactical echelons of the Army for the past 5 years, replaces teletypewriter set *EE-98* employed in World War II, has been publicized in detail and it is not considered necessary to present other than the salient features in this article.[1] The printer and accessories are contained in an immersion-proof enclosure, may be manpacked on a Quartermaster packboard and weigh one quarter of the set replaced. While the equipment operates at 100 words per minute (wpm), a large portion of the mechanism functions at one half the word speed and this, coupled with a significant reduction in number of adjustments and working parts, has greatly reduced the field maintenance problem.

The second tactical equipment, teletypewriter set *AN/GGC-3*, see Fig. 1, developed to meet requirements estab-

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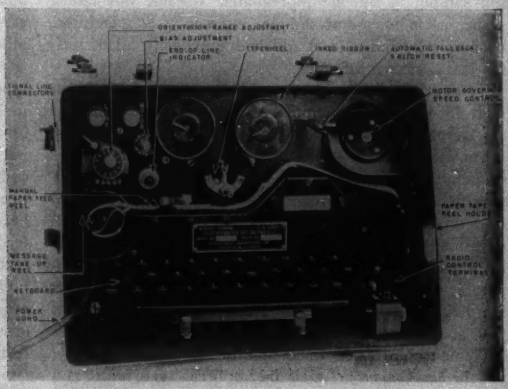


Fig. 1 (left). Teletypewriter set AN/GGC-3, ready for operation. Fig. 2. Ultralightweight teletypewriter set AN/PGC-2, interim model

lished by Continental Army Command, has been in production by Kleinschmidt Laboratories, and replaces reperforator-transmitter *TG-26*. To those familiar with the *TG-26*, the bulk and weight reduction (approximately 4 to 1) will be quite apparent from the illustration. This set, a typing reperforator with keyboard and a tape transmitter, driven by one motor, provides facilities for tape reperforation from incoming signals; local keyboard tape perforation; and transmission to line from keyboard or tape transmitter; all instantaneously selectable by means of an option switch. A built-in rectifier supplies direct current for local tape perforation and local test. It possesses all new features of the *AN/PGC-1;* including 60-, 75-, or 100-wpm operation; 20- or 60-milliampere (ma) neutral operation of the selector magnet. The tape transmitter is equipped with a 'yield"-type shuttle tape drive and a pivoted "tape-out" pin; pressure applied by the sensing pins is extremely low. Poor-quality tape may be rerun through the transmitter many times under high-humidity conditions without "embossing" and consequent false transmissions. Fully perforated tape 7/8 inch wide, with typing on the lower unperforated portion is employed, as in the new fixed-plant and switching equipments discussed later. Selection of tape 3/16 inch wider than that formerly employed was dictated by recognition of the fact that characters printed at the new higher typing speeds on the unperforated portion of the tape would be more readable for a given ribbon life than on "chadless" tape. Furthermore, photoelectric sensing is more easily accomplished with fully perforated tape. Compatibility between new and old tape equipments, was achieved by equipping all new tape transmitting equipment with universal heads, accommodating either width tape, and by developing modification kits for old-type transmitting equipment providing this facility. The *AN/GGC-3* is a typical element of the integrated series or "family" of tactical and fixed plant equipments established as a result of the basic philosophy adopted with development of the *AN/PGC-1*. In the interests of depot stock reduction, not only have the number of parts been reduced, but interchangeability or maximum use of common parts and subassemblies has been accomplished. The interchangeability factor achieved over the entire line of tactical and fixed-plant equipments is approximately 80 per cent.

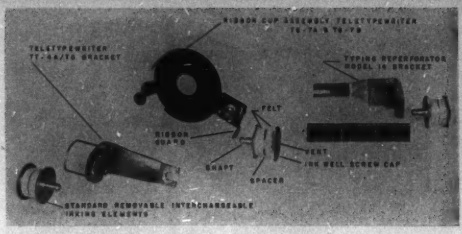
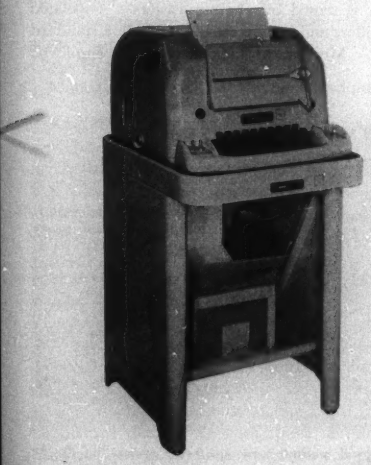


Fig. 3. Automatic teletypewriter ribbon re-inker, versions used for the new and the old equipment

The Laboratories have been engaged in developing an ultralightweight teletypewriter for extreme forward echelon use, to replace manual Morse-telegraph communication with the advantages of higher speed, elimination of human errors in receiving and transcribing copy, compatibility with on-line security devices, and lessened operator training. An interim model of a tape printer complete with voice frequency line unit, operable from a vehicular battery and packaged in an immersion-proof case, is shown in Fig. 2. Development is continuing to meet revised Service requirements.

This completes the tactical equipment development with the exception of packaged-type tape-relay sets, covered later under switching developments. Laboratory engineers have conceived and developed various teletypewriter accessories, approved by the using arms, such as the auto-



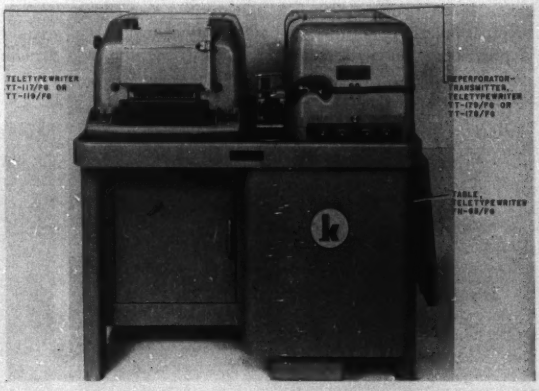

TELETYPEWRITER TT-117/FG OR TT-119/FG
REPERFORATOR-TRANSMITTER, TELETYPEWRITER TT-170/FG OR TT-178/FG
TABLE TELETYPEWRITER TG-60/FG

Fig. 4 (left). Teletypewriter set AN/FGC-20, after adjustment has been made for fan-fold sprocket feed paper. Fig. 5 (above). Teletypewriter set AN/FGC-25, design-approval model

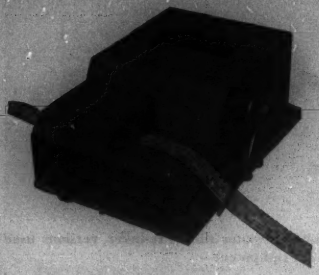


Fig. 6. Transistorized high-speed tape transmitter, experimental model

matic paper take-up mechanism for page printers and the automatic teletypewriter ribbon re-inker, which increases the useful life of ribbons by a factor of at least ten. This principle has also been introduced into all new tape relay and switching equipment design and will effect large annual savings in the operation of these equipments. Three versions of the re-inker for simple application to old and new equipments are shown in Fig. 3. The ink reservoir and applicator assembly may be quickly removed for refilling.

The first fixed-plant type of terminal equipment developed was a replacement for the model *15* set, since the necessary basic printer mechanism was already available in the *AN/PGC-1*. This set, known as teletypewriter set *AN/FGC-20* or *-21*, for communication or weather service, possesses the same new characteristics as the tactical printer. See Fig. 4. In addition, many improvements have been provided. For example, it may be adjusted for use of single-copy friction-feed paper, or multicopy, sprocket-feed paper, or fan-fold paper in a matter of minutes; the machine will receive and/or transmit on a 20- or 60-ma neutral, or 30-ma polar or "polal" basis without the need for a repeating relay although one is provided—all accomplished by means of an option switch. A miniaturized d-c power supply is built in the printer, and a "repeat" character key is provided. Automatic insertion of "carriage return" and multiple insertion of "line-feed" functions during carriage return obviates overprinting if these signals are lost in radio transmission. It has been put into production by Kleinschmidt Laboratories.

A replacement for the model *19* set having principal application in tributary stations of tape-relay centers and providing page receiving, tape perforation, and automatic tape transmission facilities, is in development-production by Kleinschmidt Laboratories. The new equipment, teletypewriter sets *AN/FGC-25* and *-26* for communication or weather service, combines all the improvements incorporated in the *AN/GGC-3* and the *AN/FGC-20* plus additional features contributing to increased versatility. See Fig. 5. Tape may be perforated on the typing reperforator from the "free" keyboard of the printer using 10-wire electric transmission with home copy on the printer; if the reperforator is simultaneously connected to a signal line, the first character of an incoming message, on a 2-wire basis, will automatically "take over" the reperforator. Provision is made for automatic response to a "query" signal when employed on a multistation line. A lineal-type character counter and tabulating device are provided on the printer. The various electrical arrangements of components and line circuits may be quickly set up by lever-type keys.

Of particular significance has been the recent initiation, by the Laboratories, of a long-term development program covering all-electronic teletypewriter equipments eventually to replace presently employed electromechanical devices. It is believed that present methods of selection, translation, printing, and tape sensing preclude reliable operation of teletypewriter equipment at speeds much over the newly established signaling speed of 100 wpm. Application of electronic techniques, including ultimate complete transistorization, will result in less specialized maintenance, radically reduced power requirements, and a broadened production base. Western Union Telegraph Company has developed, under contract, an experimental model of a high-speed tape transmitter distributor in which fully perforated tape is sensed by phototransistors. Associated transistor amplifiers and timing circuits provide a standard Baudot output. Mechanical tape stepping is employed

FULLY AUTOMATIC TAPE RELAY SYSTEM . . .
IN
OUT
PROVIDES IMMEDIATE DETECTION OF ANY CONDITION THAT COULD DELAY A MESSAGE OR RESULT IN A "LOST" MESSAGE
Automatic and Electrical Processing results in relaying a message in less than a
MINUTE

Fig. 7. Advantages of fully automatic tape relay systems

MANUAL "TORN TAPE" RELAY SYSTEM . . .
MANUAL STEPS IN RELAYING A MESSAGE
1 DETERMINE ADDRESSEE
2 DETERMINE "PRECEDENCE" (Priority)
3 RECORD INCOMING CHANNEL NUMBER
4 TEAR OFF TAPE AND CARRY TO 5
5 INSERT IN APPROPRIATE TAPE HOLDER FOR ADDRESSEE & PRECEDENCE
6 REMOVE TAPE FROM HOLDER AND INSERT IN APPROPRIATE TAPE TRANSMITTER
7 INITIATE TRANSMISSION "OUT" OF SYSTEM
EQUALS 8 minutes under average traffic conditions

Fig. 8. Typical manual torn-tape relay system in ZI

and single-character transmission by manual control is provided. The complete unit is shown in Fig. 6. The Teletype Corporation is currently developing for the Laboratories an experimental model of teletypewriter set *AN/FGC-36*, an electronic high-speed page printer. It will operate on conventional "2-wire" sequential or "10-wire" simultaneous Baudot signals (excluding the start and stop pulses) at 100 to 750 wpm and will employ impact printing. As a supplementary endeavor, Anderson-Nichols Company is conducting a research study to determine the most appropriate principle of "nonimpact" printing applicable to page teletypewriters culminating in an experimental model of the selected printing method. Combining the study results with the *AN/FGC-36* is expected to produce a satisfactory all-electronic printer.

The Laboratories have investigated the possible advantages of employing simultaneous transmission of Baudot signals (less the start and stop pulses) over five parallel channels. Preliminary results indicated an increase in information capacity of conventional teletypewriter channels of nearly 50 per cent, provided satisfactory terminal synchronizing equipment could be developed to function in the absence of the start-stop pulses. Anderson-Nichols Company is currently developing for the Laboratories experimental models of suitable local synchronizing and individual-channel delay-compensating equipment. They are conducting comparative tests of conventional sequential single-channel 100-wpm transmissions and simultaneous 750-wpm 5-channel transmissions over various media and at various signal-to-noise ratios. The *AN/FGC-36* and future reperforators will be capable of operation directly at terminals of such 5-channel systems.

Next in order is the development of various types of tape relaying and switching systems for U. S. Army use. As the result of an extensive internal study by the Laboratories it was felt that there was military application of all three recognized types of switching systems as follows:

Fully automatic—at primary tape relay centers in the continental United States or zone of interior (ZI).

Semiautomatic—at secondary tape relay centers in the zone of interior and at Army Group, Army, and possible Corps Headquarters.

Manual (torn-tape)—at Division Headquarters.

Advantages of a fully automatic tape switching system are illustrated in Fig. 7. The disadvantages of the manual or torn-tape system as currently employed are shown in Fig. 8, illustrating a typical system in the *ZI*.

First activity of the Laboratories in the design of various switching systems was the preparation of rigorous specifications for a fully automatic 20 full-duplex line system, teletypewriter switching center *AN/GGC-2(XC-1)*. This system, developed by the Automatic Electric Company, was installed in Fifth Army Headquarters, Chicago, Ill., for service test and cut over to traffic in December 1952.[2] This installation, partially shown in Fig. 7, employed World War II teletypewriter equipment and may be considered already obsolete as among other things, it cannot handle the planned network speed of 100 wpm. It has been of great value, however, in the compilation of traffic

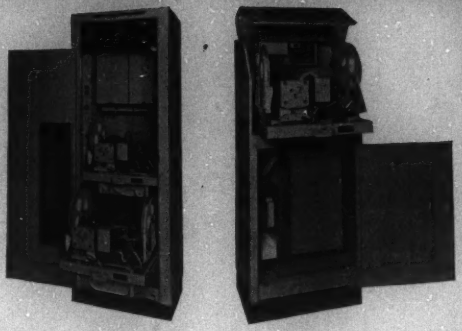


Fig. 9 (left). Incoming line unit, central office teletypewriter AN/FGC-30, experimental model. Fig. 10 (right). Cross-office unit, central office teletypewriter AN/FGC-30, experimental model

studies and other data related to the use of fully automatic teletypewriter switching in the Army Command and Administrative Network. These data have been utilized in the design and production of central office teletypewriter *AN/FGC-30*, a fully automatic tape switching system employing teletypewriter equipments which are elements of the newly established integrated family of terminal equipments, and operating in full accordance with the latest all-Service agreements on tape relay procedures. It is engineered on a basic "building-block" principle of 25 full-duplex lines with maximum capacity of 250 lines. A number of 100-line systems are currently being developed and fabricated by Automatic Electric Company and Kleinschmidt Laboratories for use in Army primary relay centers in the *ZI;* the first system to be installed in 1955. Major advantages are summarized as:

1. Designed to effect maximum use of common equipment.
2. Reception and transmission over incoming and outgoing lines may be at different speeds—60, 75, or 100 wpm. Cross-office speed is slightly higher than the highest incoming or outgoing line speed.
3. Messages are processed for destination and for six degrees of precedence, they are routed by the "director" to the cross-office equipment immediately upon receipt of routing information at the switching center. Extremely high cross-office speeds are not required, eliminating maintenance attendant upon use of high-speed equipment.
4. Channel numbers are checked as soon as the message enters the switching center.
5. A "translator," with patch panel, provides maximum flexibility and rapid adaption to change of routing indicators. Only other centers in use and tributary stations of the center require patching. Messages bearing other indicators are routed automatically to an intercept position.
6. The relay-type translator, providing answers in a matter of milliseconds, possesses capacity for a possible 936 relay centers, each having possible 702 tributary stations, for a total of 657,072 destinations. One translator is re-

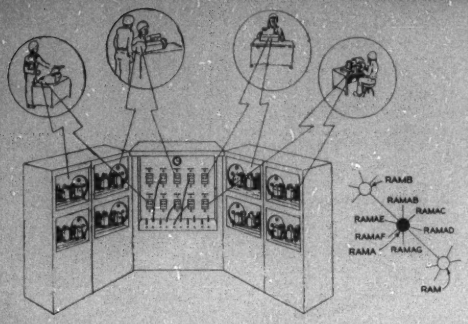


Fig. 11. Artist's conception of the basic 8-line semiautomatic tape relay system

quired for a 100-line office but a spare is furnished. All messages with Priority or higher precedence, and destined for "night-file" storage, are automatically routed to intercept for supervisory attention.

7. Routing indicators of four, five, or six characters may be processed.

8. Cross-office units, used for temporarily storing messages in accordance with outgoing line assignment and precedence, are not associated normally with any outgoing or incoming line nor with any degree of precedence, but constitute a common pool from which the director selects a unit and sets up the connections indicated. The use of the common pool provides high flexibility with a small amount of equipment.

9. Multiple-call messages are routed to cross-office units as required to route the messages to all destinations indicated. After headings have been transmitted to each cross-office unit, the text is transmitted simultaneously to all units, then the complete messages are transmitted in the same manner as single-call messages.

10. Outgoing lines are not disturbed during multiple-call message processing prior to actual transmission.

11. Outgoing multichannel selection is accomplished by simple means without line finders.

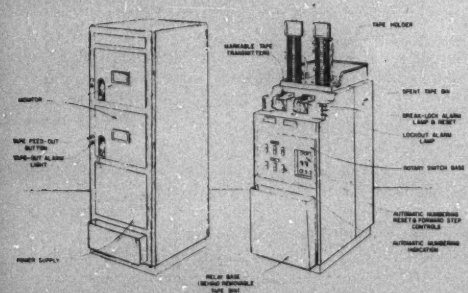


Fig. 12. Teletypewriter set AN/TGC-5, receiving (left) and transmitting (right) consoles

12. Full-duplex multistation lines are effectively handled on a terminal-per-station basis, each station having full-channel number check.

13. Incoming messages of the three highest precedences automatically "break in" on outgoing transmission of messages of lower precedence and a special transmitter automatically sends the "cancel transmission" supervisory instructions.

14. Alternate routing is provided at the outgoing terminal equipment for messages in cross-office storage. Alternate routing may also be accomplished at the routing translator unit.

15. In event of large-scale damage to the automatic equipment, the system may be easily and quickly converted to manual or torn-tape operation.

16. All tapes are printed as well as perforated so that operators may readily read the tape at any point in the center.

17. The *AN/FGC-30* may be expanded on a building-block basis in increments of two incoming lines and single cross-office units. Common equipment is designed in steps of 25 for incoming and outgoing lines, in steps of 50 for cross-office facilities. There is no practical limit on the number of channels or trunks to any one destination.

18. Indicator lamps and audible signals employed as alarms appear at both the supervisor's console and at the unit originating the alarm, and identify and locate all conditions within the center which interfere or could interfere with the normal flow of traffic. Push buttons and lamps at the console permit immediate determination of incoming-line unit connections to cross-office unit and vice versa, and similarly, connections between cross-office unit and outgoing lines. This is extremely valuable in expediting message processing and maintenance.

19. Teletypewriter equipment employed was developed and manufactured by Kleinschmidt Laboratories, and has been particularly designed for this application.

A view of an experimental model of the incoming-line unit (2-line capacity) is shown in Fig. 9. A cross-office unit (experimental model) is illustrated in Fig. 10.

The Laboratories are currently designing and fabricating, on an internal basis, an eight full-duplex-line prototype semiautomatic switching system. All operations will be automatic except for reading the destination information and appropriate plug-and-jack switching action by the operator, push-button initiation of "cancel-transmission" action, and multiple-address message processing. The system is designed for application in areas having traffic levels too high to be served efficiently by torn-tape facilities and too low to warrant employment of fully automatic switching. Elements of the new series of teletypewriter equipments will be employed, including the versatile markable tape reader-transmitter which may be marked by action of the sensing pins or by preset information from rotary stepping switches. In addition, information read by the sensing pins may be presented externally in the form of closure of 1 of 32 circuits or in simultaneous 10-wire Baudot code. It is believed possible to arrange the basic system so that one operator may handle all traffic on eight

full-duplex lines. In final form, provision will be made for expansion in increments of two lines in bookcase fashion, with all units in immersion-proof shock-mounted packages for air or vehicular transportation. See Fig. 11. It is anticipated that the prototype model will be available for informative test during 1955.

In response to an established requirement for a lightweight high-speed teletypewriter set to replace the 2-channel packaged tape relay set *AN/TGC-1*, the Laboratories decided to explore new design approaches that might result not only in an improved equipment but a unit easily and quickly assembled into a truly efficient manual or torn-tape relay center. Teletypewriter set *AN/TGC-5*, being developed by Kleinschmidt Laboratories as a result of Coles Signal Laboratory's exploration work, is illustrated in Fig. 12. The unit is divided into two consoles. One includes the new markable tape transmitters permitting automatic transmission of message channel numbers and flip-flop transmission of messages to one outgoing line; tape "washboard"; option switches for selection of "split" or "normal," half-duplex or full-duplex, 20- or 60-ma neutral operation; alarms; and power supplies. The second console includes two typing reperforators, one with take-up reel, and spent-tape bins. The reperforator assemblies are mechanically interchangeable, and the two consoles, when functioning as an *AN/TGC-5* as such, are mounted side by side with electric interconnection by plug and cable. The interchangeability feature of the reperforator assemblies and the use of interconnecting cables permit quick assembly of the consoles into a torn-tape switching system on two-for-two basis, that is, two full-duplex line capacity per two *AN/TGC-5*'s. This arrangement permits an efficient flow of hand-carried traffic in tape form between the incoming line console groups and the transmitting positions as contrasted with the confusion that inevitably resulted when the *AN/FGC-1* equipments were operated side-by-each as a manual switching system. Quantity production will start in 1956.

In addition, the Laboratories are engaged in the following related activities:

1. Development of a monitor set, applied to radio circuits terminating in the new fully automatic tape switching systems, *AN/FGC-30*, or in existing torn-tape systems, to indicate automatically when such circuits are becoming unreliable due to an incidence of "hits," "misses," or multipath effects which exceed a predetermined value. Stelma, Inc. is engaged in developing service-test models of this equipment.

2. The Western Union Telegraph Company is developing service test models of a semiautomatic teletypewriter multipoint signalling device against Laboratories specifications. This equipment, consisting of one master station and a number of tributary station equipments per multistation circuit, will be associated with fixed semiautomatic tape relay centers permitting more efficient circuit utilization.

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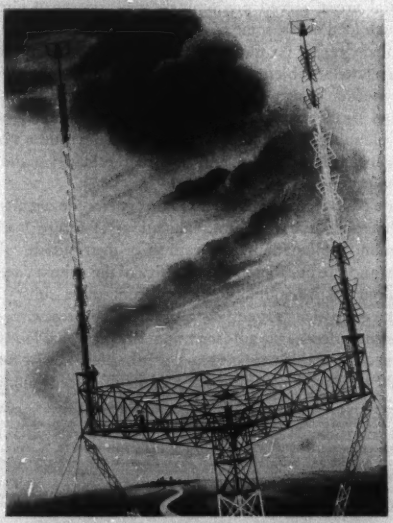
Unique TV Antenna Installation for Stations WFAA and KRLD

A Radio Corporation of America "candelabra" television antenna will enable stations WFAA and KRLD, Dallas, Tex., to share antenna site and tower and achieve the maximum height allowable under aeronautical regulations. The candelabra permits broadcasters who desire the same antenna location such advantages as equal height, the economies of a common tower, and single-site construction and erection costs. This installation provides separate antennas, a different type for each station, mounted 75 feet apart on a triangular platform on top of the antenna tower.

The two-in-one antenna installation will be 1,521 feet high, the second tallest man-made structure in the world exceeded only by a tower installation at Station KWTV, Oklahoma City, Okla.

These two antennas are design-modified to withstand winds normally anticipated at the high altitude. Station WFAA, channel 8, will be equipped with a *TF12AH*-type antenna, for an effective radiated power of 316,000 watts. Station KRLD, channel 4, will be equipped with a *TF6BM*-type, for 100,000-watt ERP. This installation will include an elevator for carrying personnel up the tower and inside the 12-foot-high platform.



Distribution-Substation and Primary-Feeder Planning

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Useful methods for distribution-substation and primary-feeder planning, based on the concept that actual distribution systems can be represented by a hypothetical system comparatively simple to construct and analyze, are presented. The methods can be used for quickly analyzing the service-quality and economic feasibility of planning alternatives or proposed changes.

ELECTRICAL-UTILITY distribution-system planning is extremely difficult because plans for the addition of new facilities must keep well ahead of the time when the exact locations and magnitudes of the future loads to be served by those facilities are known. This article presents a basis and methods for distribution-system planning which take load growth into account in such a way that exact locations and magnitudes of future loads need not be known to arrive at an economic system for serving the loads when they develop. To accomplish this, hypothetical equivalent distribution systems are devised for quickly analyzing the service quality and economic feasibility of distribution-system growth plans applicable to the load areas of the actual system being studied.

The system planning concepts and methods presented are particularly applicable to urban and suburban residential areas, served predominately by overhead circuits. In such load areas, some of the most fundamental planning problems center on the distribution substations, where the interrelated problems of subtransmission-system and primary-feeder design converge. Choice of distribution-substation arrangement, size, and voltage rating influences system planning in two directions: toward the source via the subtransmission circuits, and toward the load via the primary-feeder circuits.

The equivalent-system method recognizes the uncertainty of the exact magnitudes and locations of future loads in planning the locations and ratings of distribution substations, and the number and capability of the primary feeders required to distribute the power from these substations. In the equivalent system, each distribution substation with its primary-feeder circuits serves an area in which load density is comparable to the values existing or forecast for the actual system being studied. Results of studies made for equivalent systems, for different values of load densities, are applicable to actual systems despite wide variations in the actual locations of individual loads in the equivalent or actual system.

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HYPOTHETICAL EQUIVALENT SUBSTATION AREAS

THE HYPOTHETICAL equivalent distribution substation areas employed in these analyses have the shape of regular polygons. The number of sides to the polygon representing a load area is equal to the number of primary feeders radiating from the primary-circuit feed point, which is assumed to be located at the center of the area. The distribution substation may be located at the feed point, or may be remotely located, with one or more express primary feeders carried from the remote substation to the feed point. For example, a hypothetical area served by six circuits radiating out from a feed point would be hexagonally shaped, with each feeder carried from the center of the hexagon along an apothem or diagonal.

The use of hypothetical load areas and circuit patterns of symmetrical geometry greatly simplifies the comparison of alternative plans which may call for different sizes of distribution substation, different numbers of primary-feeder circuits, and different primary-feeder voltages. Such load areas and circuit patterns are abstractions because they do not exist exactly in such forms anywhere. These abstractions however, can be made to conform with the system they are devised to represent in all of the following ways: load density, substation size; substation or feedpoint service area in square miles; number of primary-feeder circuits, conductor material, and circuit impedance values; primary-feeder voltage.

Hypothetical distribution-substation areas cannot conform with actual systems in two ways: the exact duplication of circuit pattern, and the exact locations and magnitudes of loads. But as load grows, these two attributes of the system continually change, sometimes at so fast a rate that the system planner must spend all of his time with remedial measures or extensions in relatively small portions of the system, while the possibilities for system-wide engineering and economic benefits go uninvestigated.

DISTRIBUTION-SUBSTATION PLANNING

THE ONE PHENOMENON common to all distribution-system load areas is increasing load density. This is particularly true of the urban and suburban residential areas served by overhead primary-feeder circuits. Regardless of the plan adopted for serving such areas, load growth must be accompanied by, perhaps should be preceded by, an

equivalent increase in distribution-substation and primary-feeder capacity. Very often, in order to achieve the required increases in system capability, changes in the basic system-growth plan must be made.

There are many features of the distribution substations and primary feeders that can be changed, over any reasonable period of time, provided that continuity of service to the customers is maintained while the system is being altered or expanded. Indeed many changes are very desirable, and serve to improve system economy, quality of service, and operation. Such changes may affect all of the following: primary-feeder voltage; distribution-substation size and arrangement; number of, and routing of primary-feeder circuits; primary-feeder loading; the various applications of supplementary voltage regulators, switched and unswitched capacitors, line-sectionalizing devices, etc. Any change must eventually lead to an increase in distribution-substation capacity.

The addition of distribution-substation capacity can follow virtually an infinite variety of general plans which must fall, however, between two extremes: In one extreme, the area served from a single substation-site remains fixed, and the capacity of the substation grows with load density. In the second extreme, a fixed amount of transformer capacity is located on a given substation site, and additional transformer capacity is located at new sites as the load grows. These two extremes of distribution-system growth will be called the constant substation-area plan and the constant-substation-size plan. Between these two extremes there is an infinite variety of plans calling for both the enlarging of existing substations and the addition of new substations.

As the load grows, the evolution of distribution substations and primary feeders may proceed slowly at certain times, and rapidly at other times, depending on what steps are taken. Changes which occur rapidly may be embodied into the system before the load has increased by very much. During changes which evolve slowly, the load may increase appreciably.

Rate of load growth, with attendant system-wide increase of load density, will vary not only from one system to another, but also within individual substation areas. The engineering and economic factors determining the capability and pattern that a system should have at any given time depend on rate-of-load growth, which unfortunately is at times a highly uncertain factor. Consequently, in order to base a system plan on some limits within which the uncertainties of load growth will lie, the various steps that can be taken to increase distribution-substation and primary-feeder capacity can be divided into two general categories—those which are accomplished while load density remains constant and those usually achieved over considerably longer periods of time, during which load density increases. The accuracy of load growth forecast will determine the accuracy of the estimated time period over which such changes should be accomplished.

For short-range planning, the assumption can be made that load density remains constant. Even for short-range planning, however, any analysis which freezes load density will be recognized as not realistic, since load density in some urban and suburban residential areas increases appreciably even during time intervals measured in months. But a constant-density analysis, though it is academic, does serve the useful purpose of establishing certain limits on what can be accomplished when certain of changes are made.

SYSTEM CHANGES AT CONSTANT LOAD DENSITY

SYSTEM PLANNING often is centered about remedial measures which are required because of inadequate capability in existing distribution substations and primary feeders, or poor quality and continuity of service. Usually when distribution substations and primary-feeder circuits are inadequate from a load-carrying capability standpoint, voltage

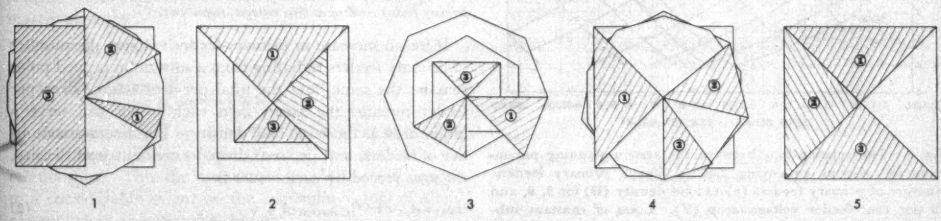

Fig. 1. Constant D, kva_{nt}, A_{nt}, V. The number of primary feeder varies as shown in equation 1. The relative values of primary-feeder voltage are: *1) kv = 1.0; 2) kv = 1.73; 3) kv = 3.0.* **Fig. 2. Constant kva_{nt}, n, kv. As load density increases while substation load remains constant, substation or feed point service area, and per-cent voltage drop in feeders vary as given by equation 6. Relative values of density, area and per-cent voltage drop are:** *1) D = 1.0, A_{st} = 1.0, V = 1.0; 2) D = 2.0, A_{st} = 0.5, V = 0.7; 3) D = 4.0, A_{st} = 0.25, V = 0.5.* **Fig. 3. Constant kva_{nt}, V, kv. As load density increases while substation load remains constant, the number of primary feeders, and substation or feed-point area vary as given by equation 7. In this relative values of density, area and per-cent voltage drop are:** *1) D = 1.0, A_{st} = 1.0, V = 1.0; 2) D = 2.0, A_{st} = 0.5, V = 1.0; 3) D 4.0, A_{st} = 0.5, V = 1.0.* **Fig. 4. Constant A_{nt}, V, kv. As load density increases while substation or feed-point area, and per-cent voltage drop in feeders remain constant, the relationship between the variable system-planning parameters is given in equation 8. The relative values of density, number of primary feeders and per-cent voltage drop are:** *1) D = 1.0, n = 4, V = 1.0; 2) D = 2.0, n = 7, V = 1.0; 3) D = 4.0, n = 10, V = 1.0.* **Fig. 5. Constant A_{nt}, n, kv. As load density increases while substation or feed-point area and number of feeder circuits remain constant, the relationship between the variable system-planning parameters is given in equation 9. In the above example, the relative values of density, number of primary feeders, and per-cent voltage drop are:** *1)D = 1.0, n = 4, V = 1.0; 2) D = 2.0, n = 4, V = 2.0; 3) D = 4.0, n = 4, V = 4.0.*

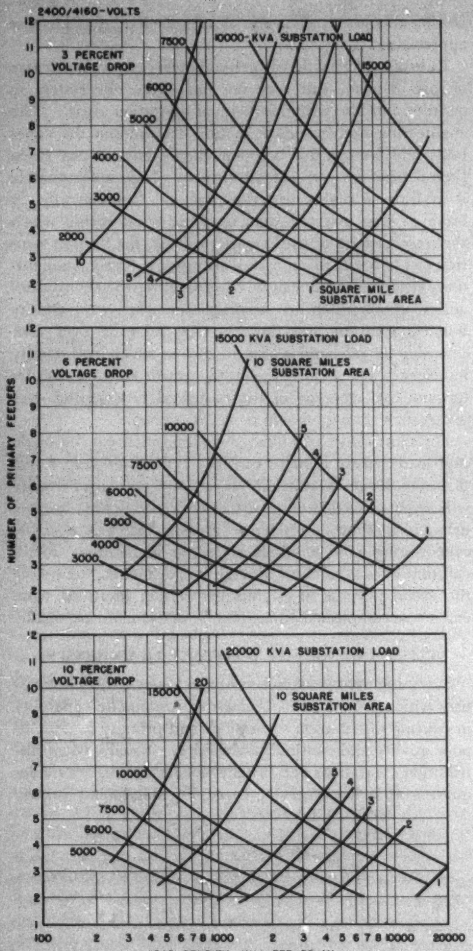

Fig. 6. The relationships between the system-planning parameters for systems employing 2,400/4,160-volt primary feeders. Number of primary feeders (n) vs load density (D) for 3, 6, and 10 per cent feeder voltage drop (V). Lines of constant substation or feedpoint loading (kva_{ns}) or constant substation or feedpoint service area (A_{ns}) are shown

drops are excessive, and outages are frequent and of long duration.

Some of the obstacles that may be encountered in attempting to achieve short-range remedies, with long-range continuing benefits, are: unavailability of new substation sites, and subtransmission and primary circuit easements; prohibiting ordinances or codes, or unfavorable civic sentiment toward more numerous or higher-voltage circuits.

Two basic types of changes to distribution substations and primary feeders will be examined while load density remains constant: those involving an increase in primary-feeder voltage; and those for which primary-feeder voltage remains the same. Equations 1–5 describe five different plans for the changing of distribution-substation size and area, or the number of primary feeders, at constant load density. Equations 1, 2, and 3 deal with feeder-voltage increase. Equations 4 and 5 show what can be done through two remedial measures applied at the existing primary-feeder voltage. Hypothetical substation areas having the shape of regular polygons may be used to demonstrate the effects of these changes, as is demonstrated in Fig. 1.

Constant Load Density—Increasing Primary-Feeder Voltage. Fig. 1 illustrates a type of system renovation that has achieved considerable popularity—increasing the primary-feeder voltage. When such an extensive and high-conversion-cost project is undertaken, there are certain factors which govern what can be accomplished. It is well known that for the same kilovolt-ampere loading, the per-cent voltage drop in a primary-feeder circuit will decrease inversely with the square of the voltage. A new voltage three times the original voltage will result in one ninth the original per-cent voltage drop. But when primary-feeder voltage is increased, optimum benefits may accrue if feeder loading or distribution-substation size is allowed to increase, at some sacrifice to the maximum possible reduction in feeder per-cent voltage drop. Fig. 1 describes a possible plan for increasing primary-feeder voltage.

At constant load density, constant substation size (and area), and constant per-cent voltage drop per feeder, the number of primary feeders varies inversely as the square of the primary-feeder voltage. The following relationship describes this effect:

$$n \propto \frac{1}{kv^2}\Big|_{\text{Constant } D,\ kva_{ns},\ A_{ns},\ V} \qquad (1)$$

In Fig. 1, hypothetical distribution-substation areas employing three relative values of voltages are illustrated: 1.0 kv, 1.73 kv, and 3.0 kv, with 18, 6 and 2 primary feeders required at these voltages, respectively.

If for an increase in primary-feeder voltage, the number of primary feeders radiating from a substation or feed point remains the same, and the total per-cent voltage drop per feeder remains the same, then each feeder can serve a larger area at the same load density. For a constant number of feeders, and per-cent drop, at constant load density, the area served by each feeder is

$$kva_{nf} \propto A_{nf} \propto kv^{A/3}\big|_{\text{Constant } D,\ n,\ V} \qquad (2)$$

In equations 1, and 2, substation-revision plans provide for maximum benefits in reduction of number of feeders or increased substation size using the same number of feeders. However, optimum economic and service-quality benefits attendant with changeover to a higher primary-feeder voltage can usually be realized if use of the same, or somewhat fewer, primary feeders is accompanied by use of a larger distribution substation.

With changeover to a higher primary-feeder voltage, three results can be achieved: reduction in number of feeders; increased substation size; reduction in feeder per-cent voltage drop. The extent by which all these desirable

benefits can be accomplished simultaneously is given by the following relationship:

$$V \propto \frac{kva_{nl}^{3/8}}{n^{3/8}kv^3}\Bigg|_{\text{Constant } D} \tag{3}$$

Constant Load Density—Utilizing the Same Primary-Feeder Voltage. Changes in substation size and primary-feeder pattern while maintaining the same primary-feeder voltage do not usually require the numerous high-initial-cost system renovations which must accompany a changeover to a higher primary-feeder voltage.

At a constant load density, with the use of the existing primary voltage, an increase in the distribution-substation capacity at a given site can be accomplished only by increasing the number of primary feeders, or increasing the loading, and consequently per-cent voltage drop, in the existing feeders.

For example, an increase of 60 per cent in feeder loading results in twice the original per-cent voltage drop, and an increase of 110 per cent in feeder loading results in three times the original per-cent voltage drop. The following relationship describes this:

$$kva_{nl} \propto A_{nl} \propto V^{3/8}\Big|_{\text{Constant } D,\ kv,\ n} \tag{4}$$

An increase in per-cent voltage drop must ordinarily be compensated for by an increased use of supplementary forms of primary-feeder voltage regulation, so that the voltage spread allocated to the primary-feeder circuit does not become excessive. Thus if total drop is increased, additional voltage regulators must be installed at points along the primary feeder so that the drop between voltage-regulated points, or between the last point on the line at which a regulator is applied, and the end of the feeder, does not exceed the allowable spread voltage in the feeder.

A method for increasing the substation capacity at a given site, with the same primary-feeder voltage and per-cent voltage drop in feeders, is to increase the number of feeders. The expression for this type of change is approximately given by

$$n \propto \frac{kva_{nl}}{\tan^{1/3}\left(\dfrac{180}{n}\text{ degrees}\right)}\Bigg|_{\text{Constant } D,\ kv,\ V} \tag{5}$$

In equation 5 it will be noted that the tangent of half the angle represented by a feeder "sector" is included in the relationship. Thus the variation of kva_{nl} with n will depend to a considerable extent on the particular values of n employed before and after the change.

In a typical example of feeder addition at constant load density and per-cent drop, an increase from four to eight feeders permits a 50-per-cent increase in substation size. Tripling the number of feeders, from 4 to 12, permits the approximate doubling of substation size.

Summary: Constant Load-Density Changes. The relationships between substation size, and primary-feeder circuit pattern as changes are made at constant load density, have been shown. The extent to which these relationships are applicable will depend on the rapidity with which changes are accomplished relative to the continual system-wide increase in load density. During short periods of time, or in particular portions of the system in which load density increases only slightly, the relationships shown in equation 1–5 are applicable. But the basic long-range system planning problems deal with increasing load density.

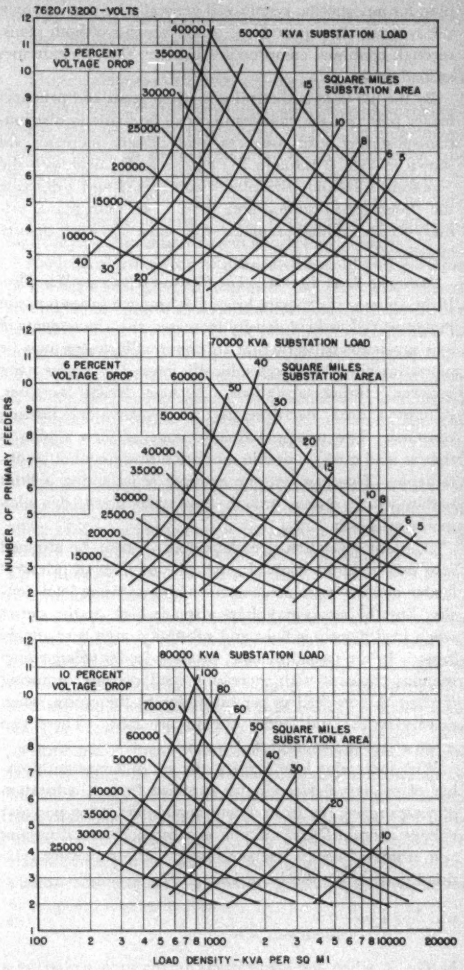
7620/13200 - VOLTS
3 PERCENT VOLTAGE DROP
50000 KVA SUBSTATION LOAD
SQUARE MILES SUBSTATION AREA
6 PERCENT VOLTAGE DROP
70000 KVA SUBSTATION LOAD
SQUARE MILES SUBSTATION AREA
10 PERCENT VOLTAGE DROP
80000 KVA SUBSTATION LOAD
SQUARE MILES SUBSTATION AREA
NUMBER OF PRIMARY FEEDERS
LOAD DENSITY - KVA PER SQ MI

Fig. 7 Same as Fig. 6, except for systems employing 7,620/13,200-volt primary-feeder circuits

SYSTEM CHANGES WITH INCREASING LOAD DENSITY

FOR MAKING SYSTEM CHANGES at increasing load density, the two extreme plans—one calling for constant substation size, and the other for constant substation area—have already been discussed. Neither type of plan permits the obtaining of maximum possible benefits in all components of the distribution system. A long-range optimum

plan for any specific system will generally be one in which the system will acquire some of the benefits of both plans, through continual compromises between the two extremes as load grows.

By the use of hypothetical substation areas and primary-feeder patterns, the changes that can be made in distribution-substation load areas as load density increases are shown in Figs. 2 through 5. Figs. 2 and 3 deal with the "constant substation-size plan," and Figs. 4 and 5 describe the "constant substation-area plan." In both plans, primary-feeder voltage remains the same as load density increases.

Increasing Load Density—The Constant Substation-Size Plan. If the amount of capacity located at any one substation site remains fixed as load density increases, then increments of new substation capacity that are continually added must be placed at new sites geographically located at points lying between existing substations. As load density increases, substation area decreases to keep substation loading constant. The principal disadvantage of such a plan is that as load grows, suitable substation sites may not be obtainable. However as one extreme representing a limit within which system growth must take place, this plan merits attention.

Constant substation-size plans may, in turn, be grouped into two basic schemes: In one, the number of primary-feeder circuits remains constant with increasing load density, but the per-cent voltage drop is high at the outset when load density is light and substation area is relatively large. In the second scheme, primary-feeder voltage drop remains constant with increasing load density, requiring the use of more feeders per substation at the outset, when density is low and feeder circuits are long. These two schemes are shown in Figs. 2 and 3.

With increasing load density, the use of a constant number of primary-feeder circuits supplied from a substation of constant size results in a continually decreasing per-cent voltage drop in feeder circuits as substation area decreases and primary feeders are shortened. The following relationship describes this behavior:

$$V \propto \frac{1}{D^{1/2}} \propto A_{sl}{}^{1/2} \Big|_{\text{Constant } kva_{sl},\ n,\ kv} \tag{6}$$

In Fig. 2, when the load density in the area served by a constant-size substation has doubled and substation-area is halved, voltage drop is reduced to 70 per cent of its original value. When load density in the still further reduced substation area is four times the original value, per-cent voltage drop is reduced to half the original amount.

With increasing load density, and constant substation size, per-cent voltage drop in primary feeders can be kept constant while the required number of feeders per substation continually decreases. Thus construction of new feeder circuits can proceed at a slower rate than substation addition. The number of feeders per substation, as a function of load density, is given by the following relationships:

$$n \propto \frac{1}{D^{1/2}} \propto A_{sl}{}^{1/2} \Big|_{\text{Constant } kva_{sl},\ V,\ kv} \tag{7}$$

In the illustration of Fig. 3, when the load density is doubled, the number of primary feeders required to serve the smaller area containing the same load is reduced from eight to six. When load density is quadrupled, the number of feeders is reduced to four. Note that the need always to consider a whole number of primary feeders will require use of the nearest larger whole number of feeders if the value for n given by equation 7 does not result in a whole number.

Increasing Load Density—The Constant Substation-Area Plan. If the size of the area served from a given substation site remains constant as load density increases, then additional transformer capacity must be placed at that site as the load within the area increases. Additional primary-feeder capacity must also be continually provided to carry the power away from the growing substation. This represents another extreme in distribution-substation planning. The advantage of not having to locate substations at new sites as load grows is counterbalanced by the need for providing new primary-feeder circuits, or increasing the load-carrying capability of existing feeders.

As the load density in a fixed area served from one site increases, to keep the per-cent voltage drop in feeder circuits constant, additional feeders must be added. In the case shown in Fig. 4, when load density and substation load have doubled, the number of primary feeders increases from four to seven. At four times the original load density, ten primary are required. The relationship between number of feeders, and substation size, for the constant-area plan is given approximately by

$$n \propto \frac{kva_{sl}}{D^{1/2}} \Big|_{\text{Constant } A_{sl},\ V,\ kv} \tag{8}$$

With substation area constant as load density increases, if more feeder circuits are not added, then the capability of the existing circuits must be more than adequate at the outset, or must be continually increased. A fixed area supplied by the same number of primary feeders as load density increases is shown in Fig. 5. The total per-cent voltage drop in each feeder increases however as the load grows, according to the following relationship:

$$V \propto kva_{sl} \propto D \big|_{\text{Constant } A_{sl},\ n,\ kv} \tag{9}$$

The capability of a constant number of feeders serving a constant area as load density increases, is limited in two ways: One limit is the thermal capability of the feeder conductors. The second limit is the maximum allowable per-cent voltage drop between voltage-regulated points on the feeder circuit. Provided that the existing feeder conductors are of adequate size to carry the load current, supplementary voltage regulators can be added along the feeders as load grows. Although the total voltage drop continually increases, this practice would keep the voltage spread along the feeders from becoming excessive.

Changes in Primary-Feeder Voltage With Load Density Increasing. Long-range system planning problems always involve increasing load densities. Often, such planning may consider increases in primary-feeder voltage. The increasing-density examples of equations 6 through 9 are based on unchanged primary-feeder voltage. The effects of increased primary-feeder voltage with increasing load density can be obtained by combining the plans of equations 1

through 5 with any one or more of those in equations 6 through 9. Such a procedure is one which "freezes" load density at several values, each larger than the preceding density. The effects of various plans can then be observed from one value of load density to the next. This technique of observing dynamic or growth situations through a number of successive static representations is a standard procedure in fields of endeavor as widely diverse as power system stability, economic theory, motion pictures, and theoretical physics.

PLANNING FOR SPECIFIC SYSTEMS OR AREAS

THE VARIOUS CHANGES by which distribution substations and primary feeders evolve are described in equations 1 through 9. The plans calling for such changes may be catalogued as follows:

1. Constant Load-Density Planning
   (*a*) Increasing primary-feeder voltage: equations 1, 2, and 3
   (*b*) Unchanged primary-feeder voltage: equations 4 and 5.
2. Increasing Load-Density Planning
   (*a*) Constant-load distribution substations: equations 6 and 7.
   (*b*) Constant-area distribution substations: equations 8 and 9.

The equations are gleaned from more comprehensive results of derivations. Since these equations deal with the physical and electrical attributes of the distribution system, substitution of wide ranges of practical values for the parameters into more complete equations yield information that can be used for the planning of specific systems. Typical results of such substitutions are shown in Figs. 6 and 7. All of the system-planning factors enumerated are represented quantitatively in Figs. 6 and 7. From these figures, the growth of a specific system following any one of the plans can be observed.

Figs. 6 and 7 are, essentially, plots showing the number of primary feeders (n) per substation or feed point versus load density (D) within the substation or feed-point service area. The variation of n with D is shown for constant substation or feed-point loading (kva_{n_t}), or constant substation or feed-point area (A_{n_t}). Fig. 6 deals with a primary-feeder voltage of 2,400/4,160 volts. Fig. 7 shows the relationships between the planning factors at 7,620/13,200 volts primary-feeder voltage. Each set (frame) of curves represents a different total per-cent voltage drop (V) in primary feeders. Curves for 3-, 6-, and 10-per-cent voltage drop are shown.

The system-planning factors, namely D, kva_{n_t}, A_{n_t}, n, kv, and V, may be followed by using these curves while one or more of the factors is kept constant, or allowed to vary. The interrelated changes in magnitude or quantity of the six parameters are given in Figs. 6 and 7. An important system-planning ingredient not included in these relationships is "time." During intervals of time over which load density increases little in certain portions of the system, the constant-density approach may be adopted for making changes. In other portions of the system, or over other periods of time during which load and density grow appreciably, the increasing-density plans may be applied.

SUMMARY AND CONCLUSIONS

USEFUL METHODS for distribution-substation and primary-feeder planning have been given. The planning methods are based on the concept that actual distribution systems can be represented by hypothetical systems which are relatively simple to construct and analyze. For the purposes of system planning, these hypothetical systems are equivalent to the actual system which they represent.

Analysis of a number of primary-feeder circuit patterns of different geometric arrangement has shown, in related studies, that distribution-substation and primary-feeder planning based on such circuit patterns are applicable to actual distribution systems. Although the ultimate locations and magnitudes of future loads will shape the growth of every distribution system, they cannot be ascertained far enough in advance to permit the exact determination of the distribution-system facilities required to serve these loads.

The exact locations of individual loads in urban-suburban areas need not be considered in studying the interrelated effect of the system-planning parameters which are: load density; distribution-substation size; primary-feeder voltage; number of feeders per substation; allowable voltage drop in feeder circuits.

The study of equivalent systems brings out the reasons for, and nature of, the compromises that must be made in distribution-system design. Several plans for changes in distribution-substation size, number of primary-feeder circuits, and feeder loading, as load density remains constant or increases, are shown (Figs. 1 through 5). The construction of these hypothetical substation areas simplifies evaluating the effects of changes made in actual distribution systems. The quantitative relationships between the system-planning parameters are derived, and are illustrated in generalized curves, (see Figs. 6 and 7). These relationships can be used for quickly analyzing the service-quality and economic feasibility of planning alternatives or proposed system changes.

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2. Useful Methods for Determining Primary Feed Points in Future Distribution System Planning, **D. L. Hopkins, D. R. Samson.** *Ibid.*, vol. 73, pt. 3, 1954, pp. 856–62.
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Nomenclature

D = Load density in kilovolt-amperes per square mile
n = Number of primary-feeder circuits emanating from a distribution substation site, or primary feed point
kva_n = The kilovolt-ampere loading per feeder
kva_{n_t} = Total kilovolt-ampere loading for all feeders of an n-feeder substation
A_n = Area in square miles served by one primary feeder
A_{n_t} = Total area in square miles served by an n-feeder substation
kv = The voltage at which a primary feeder operates
V = The total percent-voltage drop in a primary-feeder circuit

Protection Against Electric Shock From Central Office Communications Equipment

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The various precautions taken in the design of central office communications equipment to reduce to a minimum the possibility of dangerous electric shock are outlined. These include interlocks on high-voltage control equipment, series resistors used with pin jacks, protective grids, and special test probes.

WHILE SAFETY OF EMPLOYEES has always been a consideration in the design of communications equipment, until recent years hazards from electric shock have not been a serious problem since the voltages used were relatively low. Direct current of 48 volts or less has been employed for circuit operation and signaling, with some application of 130 volts. Alternating current has been employed for ringing subscriber bells, sometimes in combination with direct current, but the values have been low enough to be considered well below the limits for safety.

With the introduction of electronic facilities, higher voltages were introduced, although in many instances these higher voltages were not hazardous since it was not possible under normal conditions for a dangerous amount of current to be passed through the human body as a result of accidental contact with energized parts. However, in other cases, to insure safety to those operating and maintaining the equipment it was necessary to consider specifically in the design protection against possible shock hazards. This article outlines the various precautions taken in the design of Bell System central office communications equipment to reduce to a minimum the possibility of dangerous electric shock.

In the central office, primary power is in general received from commercial mains at a nominal 120 or 240 volts. Motor-generator sets or rectifiers are then used to float batteries for supplying the desired direct current. Alternating current for ringing purposes is also produced by motor-generator sets. No voltages higher than 48 or 130 are distributed throughout the office. Where such higher voltages are required, they are derived within the equipment in which they are used.

Equipment directly connected to commercial power service, including engine-alternator or battery-driven alternator sets to supply this power regularly or during emergency, have live parts insulated, guarded, or enclosed in cabinets. The power supplies in question generally involve operating voltages of less than 150 volts to ground. Warning signs are not considered necessary.

In the case of power used for signaling, switching, and operation of other communications equipment, the protective treatment provided is adapted to the level of voltage involved and is discussed here in three voltage categories. Such power includes battery supply, ringing, stepped-up alternating, and rectified direct voltages, and stepped-down alternating voltage not directly connected electrically to the commercial power service.

VOLTAGES UP TO 150 VOLTS

NO SPECIAL PRECAUTIONS other than design layouts to minimize accidental short circuit or personnel contact are applied for cases involving up to 150 volts to ground rms alternating current or nominal direct current, and not over 300 volts rms alternating current across any bare parts. Enclosure in cabinets is employed when the type of equipment makes such enclosure desirable. When not enclosed, certain live parts are protected by insulation.

VOLTAGES FROM 150 TO 600 VOLTS

FOR CASES OF 150–600 VOLTS to ground rms alternating or direct current, and not over 1,000 volts rms alternating current across any bare parts, insulation, isolation, and guarding are employed.

Previously for installations of this voltage range, it was the usual practice to provide a door switch to disconnect the power supply automatically when a cover was removed or a door opened. However, experience over an extensive period has led to the conclusion that maximum safety and reliability, and greater maintenance flexibility, can be secured by concentrating attention on insulation, isolation, guarding, and effective warnings, rather than placing dependence upon automatic door switches. The use of such protective devices was not particularly satisfactory where it was necessary for testing and adjusting purposes to operate the equipment with the cover removed and with normal power applied. There is a tendency for the attendant to block the safety switch rather than to apply operational safety precautions, if the voltages involved are not in a range which he considers particularly hazardous. Where a circuit runs through several cabinets, door switches in series add to the complication and the opportunity for failure. Door switches may also interrupt important circuits if a cover is removed or a hinged door is opened before the load is transferred to reserve equipment. Where carrier or other multichannel systems are involved, a single power unit

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improperly shut down may cause nation-wide trouble on hundreds of channels. While the use of door switches affords a measure of protection to unauthorized or uninformed personnel, this obviously increases the difficulties of authorized maintenance men checking circuits under operating conditions.

High-voltage bare parts are isolated. If voltages must be checked, these parts are so arranged that they will be accessible to probes while protected against accidental contact. Supplemental enclosures or shields will be used and locations of higher voltages presenting possible hazard, such as 300 to 600 volts, will be marked with the maximum voltage involved if this appears to be practicable and useful. Pin jacks are brought out where necessary to make reading points accessible. High-voltage points requiring checking only at long intervals are protected by removable barriers fastened with screws or clips.

Appropriate warning signs are provided consisting of a metal plate or decalcomania reading "Warning—Hazardous Voltages" with the world "Underneath" added where appropriate. If the removal of an outer cover exposes live parts, the warning is applied to the outer enclosure. If all high-voltage parts are segregated and are under another inside cover or an inside guard, the warning is located on the inner cover or associated with the guard. The warning designation is placed in a prominent location visible both when guards are in place and when they have been removed for equipment repairs after power has been disconnected.

This voltage range covers most of the plate-voltage rectifiers and other power sources operating at 130 volts output or higher since they will have voltages higher than 150 volts to ground across parts. By improving the isolating and guarding, and omitting the door switch, it is believed that greater safety during field operation is secured and accidental opening of working circuits is minimized. Point-to-point voltage readings specified in maintenance instructions are also facilitated.

A rectifier for the *TD-2* radio relay system which exemplifies an equipment arrangement for the class of voltage under discussion is shown in Fig. 1.

High-Voltage Panel. For this rectifier the components above 150 volts are segregated on the upper panel; values of 600 volts are not exceeded. The panel is covered by a transparent plastic grid. By the use of this type of grid accidental contacts with live parts are prevented, but meter readings can be taken if necessary by the insertion of test probes through the grid. A warning sign is provided and located in such a position that attention will be drawn to it even with the grid in place. The sign remains on the panel when the grid is removed. The removal of the grid may be necessary to replace defective components, but the rectifier should be disconnected from its power source before the removal of a grid and not reconnected until the grid is replaced.

Low-Voltage Panel. The terminals and equipment on the lower panel and the hinged meter panel operate at less than 150 volts to ground, and are not considered hazardous to a maintenance man working on the equipment. During normal operation, a grounded metal cover encloses all live parts so nothing carrying voltage can be touched. Normal operation does not require removal of this cover.

VOLTAGES OVER 600 VOLTS

Power supply and other equipment involving voltages over 600 volts to ground rms alternating current or direct current, or over 1,000 volts rms alternating current across any bare parts, usually have a limited number of parts at high voltage associated with other parts operating on low voltage. *L* carrier is an example of this class.

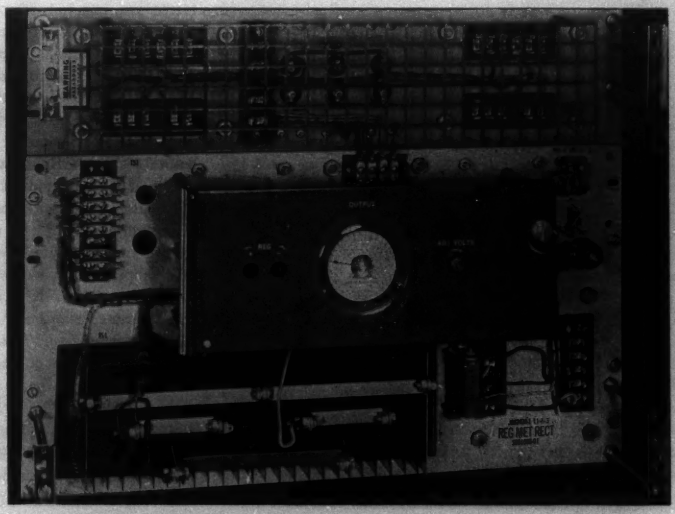


Fig. 1. TD-2 radio relay system—24-volt regulated rectifier, shown front view wtih the cover removed and the hinged meter panel closed

The high-voltage apparatus is isolated in a supplementary enclosure equipped with an automatic door switch and marked with a warning including the value of the maximum voltage. If some of the high-voltage equipment cannot be isolated, live parts are separately guarded and marked. Pin jacks are brought out to facilitate taking of high-voltage readings where these are necessary under operating conditions. A warning sign is provided on the inner enclosure, to caution against possible interruption to service as well as against high voltages. In addition to the sign, there is stamped on the cover adjacent to the sign the approximate maximum value of the voltage across equipment terminals or to ground, such as 2,500 volts. The remaining lower voltage apparatus, if any, belonging to the high-voltage plant, is protected in accordance with the methods previously given, depending upon the classification of the apparatus outside of the inner enclosures. Usually an outer enclosure not equipped with a door switch will be supplied. There may, however, be cases where all the equipment is high voltage, or where only the high-voltage equipment need be enclosed, in which event a single enclosure only is used and the protection recommended in the previous paragraphs is applied.

HIGH-VOLTAGE CONTROL INTERLOCKS EQUIPMENT

In certain types of plants it is necessary to perform maintenance operations on high-voltage equipment while the plant remains in service, and consideration is given to the use of key interlocks instead of door switches. One example is a 250-volt storage-battery rectifier plant for plate supply. This includes a 56-cell battery plant added to the regular ±130-volt supply. Duplicate battery sections are provided, each in a separate locked cabinet, so that one section may be entirely disconnected for routine maintenance purposes while the remaining section floats across the rectifier carrying the office load. A key interlocking system prevents access to a cabinet without disconnecting its battery from the circuit. Each section is equipped with an ON–OFF switch, which is mechanically interconnected with three lock mechanisms. One lock prevents the switch from being operated to its OFF position until a master key has been inserted and turned. Two cabinet keys, one each for the front and rear cabinet doors of the section, are held in the other locking mechanisms until the switch is turned to the OFF position. The switch cannot be operated to its ON position again until both cabinet keys are restored to their proper locations in the supplementary locks. With the switch once thrown to its OFF position, the master key is "seized" and cannot be withdrawn so that the switch in the other section cannot be opened. This feature is provided to guard against disconnecting the load. When one of the cabinet doors is opened, its key is seized until the door is again closed and locked. Thus the operation of the ON–OFF switch to its ON position is prevented if one of the cabinet doors is open. With the switch operated to the OFF position, the battery section is ungrounded and the maximum voltage obtainable is less than 120 volts. This particular system uses eight interlocks. More extensive plans have been developed for higher voltage systems for other uses.

CHECKING VOLTAGES

The previously described arrangements should permit safe maintenance and checking of all except the highest voltage units without taking the power plant out of service. The high voltages can also be checked while operating to the extent that pin jacks are provided, but the equipment must be shut down for other maintenance activities. Where jacks are not provided for taking certain infrequent high-voltage readings, temporary wiring to meters may be installed in some cases and the door reclosed while taking readings. It is preferable that the meters be located behind transparent panels, and that temporary high-voltage caution signs be placed to warn personnel in that vicinity. If the voltmeter has a multiplier, this should be connected so that the meter will be on the grounded side, if any.

USE OF SERIES RESISTORS WITH PIN JACKS

The highest voltage standard portable instrument ordinarily available will be one having a maximum reading of 600 volts. On high-voltage equipment it will often be possible to read operating voltages by permanently installed panel voltmeters forming part of the equipment. Where point-to-point voltages of equipment over 600 volts to ground must be checked, consideration is given in the design to bringing out pin jacks to read a definite fraction of the high voltage to ground. One way of doing this is to put high series resistors between the voltage sources and the pin jacks which will act as built-in multipliers for the particular meter to be used. This should limit the current to about half a mil, which is harmless even if the meter terminals should be accidentally touched.

It would also be possible to bring out the pin jacks from voltage dividers or potentiometers but this is not considered suitable under most conditions. Readings would be wrong if there were trouble in the divider and the high voltages up to full value would be put on the voltmeter if the divider connection to ground should be open. This would create a serious hazard to the attendant. For high-voltage low-current supplies, as are used for cathode-ray tube accelerating anode potentials, consideration is given to providing inherent current-limiting features.

PROTECTIVE GRIDS

A red-tinted plastic insulating grid has been made available for use in protecting against accidental contact with parts connected to voltages principally in the 150–600 class. This grid has ribs approximately $^1/_8$ inch in cross section spaced to provide openings about $^3/_4$ inch square through which test probes can be inserted. The grid is preferably located to provide a clearance of $^3/_4$ to 1 inch between the grid and live parts but in no case is this clearance less than $^1/_4$ inch. It is held in place with clips arranged to permit ready removal of the grid if replacement of circuit components becomes necessary.

TEST PROBES

Two special test probes with enclosed voltage multipliers have been made available. One of these provides a multiplier for use on voltages up to 3,000 volts. It is suitably insulated so that a craftsman can manipulate it in

taking readings without introducing a shock hazard. The other test probe is intended for use on up to 12,000 volts and has an enclosed 240-megohm series resistance. This type of device is intended for use in connection with video amplifiers and certain radio transmitters. It is arranged to be clipped to the point at which a reading is desired and the meter end of the attached lead is hooked to the associated meter with a special safety connecting device to give full insulating protection from the inner live parts should the connector inadvertently be attached or removed from the meter while the probe is connected with working voltages. The probe proper is highly insulated for protection should it be necessary to hold the probe in position manually while taking a reading.

Another test probe for use on lower voltages has been made available. Although this device is not intended primarily to insure against high-voltage shock, it is, however, insulated to avoid contact by the user with the metallic inner parts of the tool. The contact member is surrounded by a retractable spring-loaded insulated tube which prevents undesired contacting with circuit elements. The contact member is not thrust forward to the opening of the tube for making connection with a circuit element until pressure is exerted against the spring towards the equipment under test. The tip of the contacting member is of hardened steel sharply serrated to produce several sharpened points. This feature tends to prevent slippage off the desired point of contact.

MEANS FOR DISCONNECTION

ALL DEVICES IN ANY OF THE THREE VOLTAGE CLASSES can be disconnected locally without the necessity of going to a distant fuse panel. If a flexible cord is plugged into a power-supply outlet, this may be used. A toggle-type or other enclosed switch which indicates power ON or OFF may be employed. In some cases a fuse of the "Saf-to-fuse" or similar enclosed type may be used to disconnect the equipment locally for maintenance.

DISCHARGING OF CAPACITORS

IF CAPACITORS ARE OF SUFFICIENT SIZE to store harmful energy, the circuit is normally provided with drainage resistors or other means to insure that any high-voltage charge leaks to ground promptly after power is removed. If this is impracticable they are marked with a warning and instructions are provided to cover a suitable method of discharging.

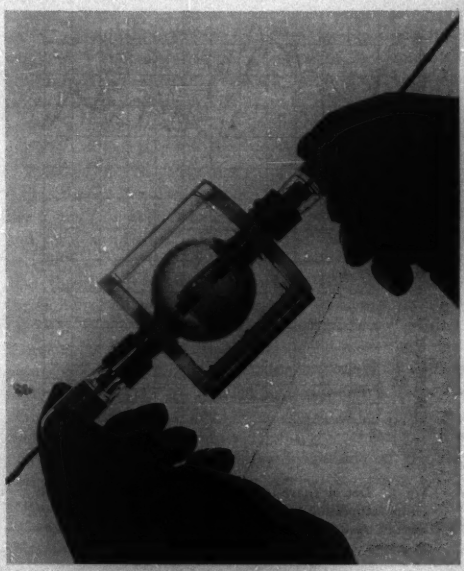
MECHANICAL LAYOUT OF COMPONENTS

IN LOCATING PARTS, such as potentiometers, which may require adjustment by screwdrivers or other tools while voltage is applied, care is taken to provide a free path for the tool so it will not come into contact with live parts during adjustment or in the event that it should slip off the screw head. The same applies to location of live parts which must be reached by voltmeter probes. Such probes are insulated for most of their length.

1,000-Watt Short-Arc Mercury-Xenon Lamp for the U. S. Navy

This 1,000-watt short-arc mercury-xenon lamp is shown housed in the plastic outer case used during shipment and handling. Tungsten electrodes, spaced a quarter of an inch apart, can be seen in center of 2-inch spherical quartz bulb. It is in the short gap between the two electrodes that the arc "jumps" in producing the light that is then directed by the searchlight reflector into the required beam. Approximately one fourth of the bulb's inner surface is coated with platinum, which serves as a heat reflector and aids in the quick starting of the lamp. The location and shape of the heat reflector are such that they do not interfere with the beam but actually reduce the problem of "spill" light from the searchlight. Xenon gas in the lamp arcs immediately and supplies heat to raise the mercury to its vaporizing temperature, and produces light equal to about 25 per cent of the lamp's final output.

The 12-inch Navy searchlights are used both for sending messages by the Morse code blinker system, and for general searchlight work. The new lamps will be installed in such a way that by the simple flick of a lever their beams can be put in and out of focus. When focused, the lamp produces approximately three-million beam candlepower and provides the maximum amount of light in a given area for searchlight operation. When out of focus, the signalling beam is wider and seen more easily when the ship rolls.



Residential Electric Space Heating in Detroit

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R. P. WOODWARD

SINCE 1949, there has been a slow but steady growth in the number of homes with electric radiant-panel heating in The Detroit Edison Company service area. While most of the early installations were in homes previously heated by other methods, there has been a definite trend in the past year or two to new homes designed and insulated for this type of heating.

The 29 homes in this study ranged in size from three to six rooms with an average of 5.0 rooms. Nineteen of the 29 were fully insulated while 10 had insulation in ceilings and walls but not in the floors. The volume of heated space (inside measurements) varied from 3,830 to 16,381 cubic feet, with an average of 7,644.

The average connected load of the heating units was 8.83 kw, the smallest being 5.0 kw and the largest 22.75 kw. Based on these figures the average installation had a theoretical output of 30,137 Btu per hour. This is 72 per cent of the average calculated heat loss of 41,785 Btu per hour based on design temperatures of −10 F and 70 F. In only three of these homes does the theoretical output exceed the calculated heat loss and five more are between 80 and 100 per cent.

Annual energy use for space heating averaged 11,412 kwhr of a total of 14,560 kwhr per customer. The other use of 3,148 kwhr indicates that customers with electric heating use almost half again as much electricity for other than house heating as the average Detroit Edison domestic customer. Even these high-use customers require almost four times as much electricity for their heating in a mild winter as they do for lighting and appliances.

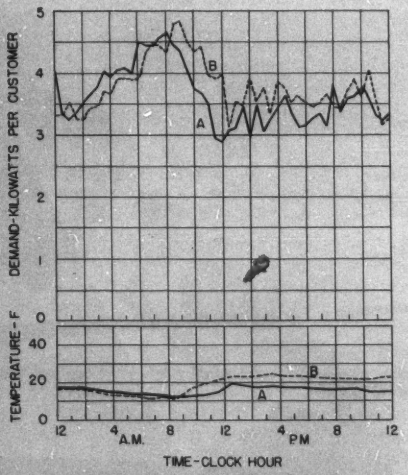

Fig. 1. Detroit space-heating coincident load curves and temperatures for 1952–1953 heating season. *A—coldest weekday, January 6, 1953; B—high use and demand day, January 7, 1953*

One of the factors frequently used in comparing electric heating installations has been kilowatt-hours per degree day per 1,000 cubic feet of heated space.

A more meaningful ratio is kilowatt-hours per degree day divided by 1,000-Btu hourly heat loss per degree of designed temperature differential. This is a restatement of the formula prepared by the Federal Housing Authority for calculating the electric energy for space heating, and should yield a value of 5 for radiant panels according to their estimates. The average of the 29 Detroit installations was 3.76 with a range from 1.36 to 7.12 but there is a tendency for these values to group together with the exception of one very high and one very low instance.

The maximum 30-minute coincident demand of the test customers was 4.77 kw, reached on January 7, 1953, from 8:30 to 9:00 a.m. when the minimum weekday temperature of 11 F occurred. The average noncoincident maximum demand was 7.18 kw. Annual load factors were 27.3 per cent and 18.1 per cent based on the coincident and noncoincident demands respectively. Based on data available for the past four heating seasons, it appears that the coincident maximum demand would be about 6.4 kw with the design temperature of −10 F. The average annual use would be about 12,500 kwhr during a heating season.

Daily load curves of the average of the 29 customers for January 6, 1953, (the day with the greatest number of degree days) and January 7, 1953, (the day with the minimum temperature) are shown on Fig. 1 along with hourly outdoor temperatures. On January 6 there were 49 degree days, the average use per customer was 86.9 kwhr and the maximum coincident demand was 4.63 kw. There were 47 degree days on January 7 with 90.8 kwhr used per customer and a maximum demand of 4.77 kw.

The cost to the customer of electric space heating at current residential rates, even with the small and well-insulated home, is in the neighborhood of $275 per season. Some of the larger homes may run as high as $600. This does not compare favorably with the present costs for other forms of heating.

From the utility standpoint the cost to serve this type of load, with a high demand occuring during the winter period and a load factor lower than that of the present residence customer, may well be excessive when compared with other domestic uses. With widespread growth in the use of air conditioning, electric heating may be an offsetting load.

Digest of paper 55-232, "Residential Electric Space Heating in Detroit for 1952–1953 Season," recommended by the AIEE Committee on Domestic and Commercial Applications and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in AIEE *Applications and Industry*, July 1955, pp. 200–04.

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Rectified Single-Phase Power for Traction Motors

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FOR YEARS attempts have been made to power locomotives by 25-cycle single-phase rectified voltage applied to d-c series motors. Early efforts were unsuccessful, mainly because of the faulty operation of the mercury-arc rectifiers. Continued research and development, however, made operation of d-c traction motors on mercury-arc rectifiers entirely feasible. The problem of such operation resolves itself into the problem of smoothing the undulating current sufficiently to avoid harmful effects on the motor.

Eddy Current. Eddy currents produced in the magnetic circuit of a motor give rise to two undesirable effects. First, if the eddy currents are of sufficient magnitude they retard the response of the commutating pole flux, thus impairing commutation. Second, the eddy currents introduce an iron loss in the motor, thus reducing its efficiency. The total iron loss occurring in the motor as the result of the eddy currents may be divided into two parts: (1) that in the armature and pole faces, caused by the rotation of the armature; and (2) that in the entire magnetic circuit, caused by the pulsating magnetic field. The former occurs in any motor, whether operating on direct current or not, while the latter is the result of a ripple current flowing in the motor circuit. Eddy-current effects can be reduced to a tolerable value by completely laminating the magnetic structure, or by inserting a smoothing reactor in the circuit to limit the ripple current.

Commutation. Commutation is one of the most important design considerations in a d-c machine. The addition of a 50-cycle ripple superimposed on the direct current resulting from rectifying single-phase 25-cycle alternating current can impair commutation. The greatest difficulty will be encountered if the pulsating component of the commutating flux produced by the ripple current is not exactly proportional at every instant to the ripple current flowing in the armature. This results if eddy currents of appreciable magnitude circulate in the solid magnet frame and commutating pole bodies. Under these circumstances the resulting damped ripple component of the commutating flux will cause the instantaneous flux to be either too great or too small, even though the average value of commutating flux is correct in magnitude. If the ripple current and this angle of lag are too great, the result will be sparking at the brushes.

Another interesting phenomenon that must be taken into consideration is the effect of the undulating flux present in the main exciting field circuit. In a d-c motor carrying ripple current the variation of this flux generates an electromotive force (emf) in the coil short-circuited under the brush. With the armature coil mid-way between the exciting field poles, no emf is generated by the rotation of the coil through the magnetic field. The coil, however, encloses the maximum field flux. Since this flux is varying because of the ripple current, the emf it induces by transformer action is a maximum. This emf which lags the varying field flux by 90 degrees, is proportional to both the magnitude and frequency of the ripple current present in the exciting field circuit, but is independent of the speed of rotation. Fortunately, the eddy currents induced in the solid magnet frame so reduce the magnitude of the varying flux at the main exciting pole air gap that commutation is not noticeably influenced.

Since the commutation of a d-c motor operating on rectified power is directly affected by the magnitude of the ripple current present in its circuit, it is essential to limit this current sufficiently to assure acceptable commutation throughout the load range over which the motor is to operate. The obvious means of doing this is by the use of a smoothing reactor in the motor circuit. Before determining the amount of smoothing reactor required from the standpoint of motor commutation, it is necessary to establish the maximum sparking at the brushes that can be tolerated without undesirable commutator pitting and excessive brush wear. Commutation tests were continued to determine the size of smoothing reactor required to give performance comparable to its nominal d-c application.

Heating. Motor heating is as important as commutation. As mentioned before, the pulsating flux in the motor is greatly damped by the eddy currents induced in the solid magnet frame. These cause a core loss which increases the operating temperature of the frame and the heating of field windings. The operating temperature of the laminated armature is not noticeably affected by the presence of the ripple current because by its rotation it is normally subjected to frequencies and magnitudes of the armature flux variation in excess of that produced by the ripple current.

Smoothing Reactor. The design of smoothing reactor for this motor can be varied to suit space and weight limitations. For locomotive application, these reactors are kept as small and light as possible. This requires that the reactor be designed around the commutating ability of the motor. The theoretical commutating ability of a motor varies throughout its load range of operation. Motor application for high values of current is generally limited by heating, therefore the voltage application is lowered. For low values of current, motor application is limited by voltage (primarily volts per bar), which for this motor is in the vicinity of 1,100 volts. The characteristics of the motor are such that the allowable ripple current (a-c component) is a constant value regardless of the magnitude of the d-c component. This permits the use of a reactor which saturates with load. The resultant design is smaller and lighter than one of the nonsaturating type with sufficient inductance to limit the ripple current when necessary.

Digest of paper 55-203, "Considerations in Applying D-C Traction Motors on Rectified Single-Phase Power," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in AIEE *Applications and Industry*, July 1955, pp. 176–9.

M. Simon is with General Electric Company, Erie, Pa.

INSTITUTE ACTIVITIES

New Will County generating plant, Commonwealth Edison System

Fall Meeting Program Will Feature Communication and Rotating Machinery

FOR THE SECOND YEAR in succession, AIEE's Fall General Meeting will take place in Chicago, Ill. This year's meeting will be held October 3–7 with headquarters again at the Morrison Hotel. The entire facilities of the Morrison will be occupied by AIEE during the 5-day meeting. Chicago is the center of one of the greatest diversified industrial areas in the world and its easy accessibility by air, rail, and automobile from all parts of the continent makes it an unusually favorable place for this important meeting.

Technical Sessions

A large and varied technical program has been planned with special attention given to the subjects of rotating machinery and communication. Seven sessions will be on rotating machinery and six sessions on aspects of electrical communication, including two on television and aural broadcasting. The new Committee on Dielectrics has organized two sessions and sessions are also scheduled by the Committees on Education, Management, and Safety.

Social Activities

Reception Tea and Hospitality Hour. Social activities will begin Sunday afternoon, October 2, from 4:00 to 6:00 p.m. An informal reception tea and a hospitality hour sponsored by the Chicago Section will be held for members and their families.

Smoker. This event is planned for Monday evening, October 3, and will coincide with a cocktail party and dinner for the ladies. The Smoker will consist of a dinner and excellent entertainment in the Terrace Casino of the Morrison Hotel. Address requests for tickets to: Edward H. Finch, Sargent & Lundy, 140 South Dearborn Street, Chicago 3, Ill. Tickets are $10.00 each and all requests should be accompanied by a remittance of $10.00 to insure a reservation. Members who want to attend this Smoker should send reservations early since the National Electronics Conference (NEC), being held in Chicago that same week, has been invited to participate in the Smoker. This, plus the success of last year's smoker, virtually insures a sell-out. The capacity of the Terrace Casino is limited to about 1,100 persons.

NEC Party. Arrangements have been made to have AIEE members attend the NEC Party, rather than stage one which would be in competition. This party will be held Tuesday night, October 4, at the Sherman Hotel. Tickets cost $6.50. Send requests together with remittance to Merlin J. Adams, Westinghouse Electric Corporation, Merchandise Mart Plaza, Chicago 80, Ill.

Ladies' Program

A full and varied program for the ladies has been arranged by Mrs. Robert B. Gear and her committee. This includes the informal reception tea on Sunday afternoon and the cocktail party and dinner on Monday night when the men attend the Smoker. The cocktail party will take place at the Gold Key Club of Chez Paree from 5:00 to 7:00 p.m. and is by courtesy of General Cable Corporation. A famous Chez Paree dinner and entertainment will follow. Also, three door prizes will be given. Tickets, *not* including transportation, will be $5.50.

On Wednesday at 12:30 p.m. there will be a style show and luncheon at Marshall Field and Company, courtesy of the Delta-Star Electric Division of H. K. Porter Company. Door prizes will be given at this luncheon also.

Other social events for the ladies include a card party with door prizes and a tea, courtesy of the Allis Chalmers Company.

Trip to Museum of Science and Industry. On Thursday, at 10:30 a.m., there will be a trip to the Chicago Museum of Science and Industry to which the men are also invited. This will provide an opportunity to see hundreds of interesting exhibits from all sciences and industries, and a special show in the museum theater.

You Pick It—We'll Take You. Since no prearranged schedule can meet everyone's desires, ladies are invited to name places they would like to visit. Hostesses will be available to help arrange these trips. Among them might be: Chicago Historical Society, Chicago Art Institute, Adler Planetarium, Shed Aquarium, Chicago Natural

History Museum, department stores such as Marshall Field and Company and Carson Pirie Scott and Company, other retail stores, Chicago University, Northwestern University, etc.

Coffee Hour. From 9:00 to 10:30 each morning coffee and rolls will be served in the Ladies' Headquarters, and hostesses will be in attendance to explain the program and help the ladies choose their entertainment.

Radio, Television, and Theater Tickets

Free radio and television tickets will be available for all days of the convention. Tickets should be secured a day in advance and information concerning programs, show times, and seating will be available at hotel headquarters.

Theater tickets and tickets for sporting events will be available only from the hotel ticket broker in the lobby.

Hotel Reservations

A sufficient number of rooms have been set aside at the Morrison Hotel, Madison and Clark Streets, to accommodate all those planning to attend the meeting.

Rates per day at the Morrison Hotel are

Single Room (one person)	$ 5.00 to $12.00
Double Room—Double Bed (two persons)	7.50 to 15.50
Double Room—Twin Beds (two persons)	11.50 to 16.00
Two Room Suite; Parlor, Bedroom	25.00 to 41.00

All rooms with bath, Servidor, and ice water.

For the convenience of those expecting to attend the meeting, an advance room reservation card will be enclosed with mailed announcements. It is suggested that this be mailed by September 20 to insure accommodations. If this card is misplaced, a request by letter to the Morrison Hotel should mention that the reservation is in connection with AIEE.

As the first week in Chicago will be a full one for all hotels, those planning to arrive at the Morrison after 6:00 p.m. and who want to make sure they will have sleeping accommodations must make a deposit of $5.00 for a single room and $10.00 for a double room. This will be refunded if the room cannot be used and the Morrison is notified in time.

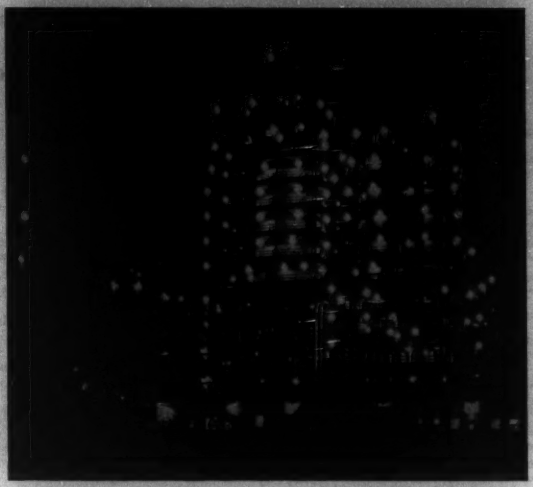
If assistance is needed in obtaining a room, contact F. D. Hurd, Hotel Arrangements Committee, Pioneer Service and Engineering Company, 231 South La Salle Street, Chicago 4, Ill.

Inspection Trips

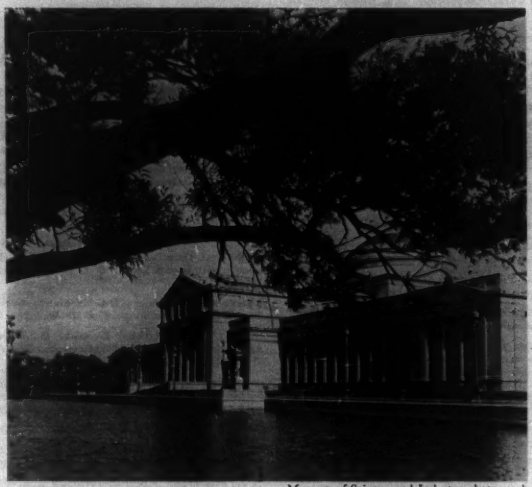
A number of interesting inspection trips are planned for the week of the meeting. Among these are tours of the Ford aircraft plant, the Standard Oil refinery at Whiting, Ind., the electromotive plant of General Motors Corporation at LaGrange, Ill., the Rauland Corporation, the new Will County station of the Commonwealth Edison Company, Reynolds Metals Company, and the new Prudential Building.

Members are asked to register in advance for all trips as the number that can be taken for each trip is limited. In making reservations please include names, citizenship, business connections, and checks for bus fees if required. Aliens should give advance notice

(*Continued on page 820*)



NIGHT VIEW of a continuous process unit at the Whiting refinery of the Standard Oil Company (Indiana) is shown above. The refinery is equipped to process an annual average of 210,000 barrels per day of crude oil. There is no connection with a utility company. The refinery generates and distributes all of the power required for its entire operation. Total generating capacity is 64,000 kw.



Museum of Science and Industry photograph

THE MUSEUM OF SCIENCE AND INDUSTRY contains exhibits of scientific and industrial progress. Ladies who attend the Fall General Meeting may see these exhibits as a tour of the museum is one of the many inspection trips that have been planned by the ladies committee. Exhibits are arranged by subject into sections, such as "fuels and metals." Each section is grouped into sequences, often tracing an idea from its invention to mass production. The men are also invited to visit the museum and to see the hundreds of interesting displays, as well as a special show in the museum theater.

AIEE Fall General Meeting, Chicago, Ill., October 3–7, 1955

Tentative Technical Program

Monday, October 3

9:00 a.m. Instruments and Measurements

55-737.† I. A Method of Making Screen Room Interference Measurements. *K. E. Mortenson, C. J. Truax*, Rensselaer Polytechnic Institute

CP.* Calorimetric Power Meters. *Max Sucher*, Polytechnic Institute of Brooklyn

CP.* Reproducing a Shaft Rotation by Digital Coding. *Ivan Flores*, Queens, N. Y.

9:00 a.m. X-Ray Engineering

CP.* Cine-Radiography with Image Amplification. *F. J. Euler, P. A. Virbal*, Westinghouse Electric Corporation

CP.* Engineering Progress in the Design of Rotating Anode X-Ray Tubes. *R. W. Cohen*, Dunlee Corporation

CP.* Design Concepts of Modern Phototimers. *R. Godbarsen, Jr.*, General Electric Company

55-739. I. Use of Proportional Counters in X-Ray Diffraction. *H. R. Laird, M. J. Zwick*, General Electric Company. Re-presented for discussion

55-740. I. A Symmetrical Transistor Oscillator with Low Second-Harmonic Distortion. *W. M. Grim, Jr.*, General Electronic Laboratories, Inc. Re-presented for discussion

9:00 a.m. Safety

CP.* Factoring the Human Equation Into Electrical Testing. *C. R. DeRosmer, H. E. Vann*, General Electric Company

CP.* Serviceableness of Flexible Cord from the Standpoint of Safety to Life and Property. *F. V. Paradise*, Underwriters' Laboratories, Inc.

CP.* The Grounding of Electric Equipment in Farm and Rural Occupancies. *O. K. Coleman*, Duncan Electric Company

9:00 a.m. Mining and Metal

CP.* Characteristics and Ratings of Electric Motors for Drills in Mines. *Ben Harbage*, Jeffrey Manufacturing Company

CP.* Effect of Voltage Variations on Mining Machine Motor Performance. *Frank Terrant*, Reliance Electric and Engineering Company

CP.* A-C Drives for Mine Belt Conveyors. *W. R. Morton*, General Electric Company

CP.* Modern Diesel-Electric Railway Cranes. *S. E. Wallin*, Bucyrus-Erie Company

9:00 a.m. Solid-State Devices

CP.* Square Loop Materials for the Timing of Multivibrators. *H. J. Venema*

CP.* The Ferroresonant Trigger Pair: Analysis and Design. *C. F. Spitzer*, General Electric Company

CP.* Switching Wave Shapes in Ferroelectric Storage Capacitors. *C. F. Pulvari*

CP.* Major and Minor Hysteresis Loops in Dielectric Amplifiers. *Earl Wingrove, Louis Dopian*, Carnegie Institute of Technology

2:00 p.m. General Session

Introduction of General Committee. F. A. Cox, chairman
Address of Welcome. A. V. Kahler, Illinois Bell Telephone Company
Response. President M. D. Hooven
Address. J. A. Hutcheson, Westinghouse Electric Corporation

Tuesday, October 4

9:00 a.m. Basic Sciences

55-705. I. Analysis of a Triode Oscillator with Losses Associated with the Inductive Branch and Signal Applied in Grid Circuit. *A. E. Mostafa*, Alexandria University

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SEND ORDER and remittance to:

AIEE Order Department
33 West 39th Street,
New York 18, N. Y.

55-706. I. Transfer Functions for Amplitude Modulated Signals. *H. Hellerman*, Syracuse University

55-707. I. What is a Minimum-Phase Network? *N. Balabanian, W. R. LePage*, Syracuse University

55-708. I. The Underwater Spark; A Photographic Light Source of High Intrinsic Brilliance. *H. C. Early, E. A. Martin*, University of Michigan

CP.* Equations for the Inductance and Short-Circuit Forces of Busses Comprised of Right-Angled Conductors Back to Back. *T. J. Higgins, Hsu Chen*, University of Wisconsin

9:00 a.m. Transmission and Distribution

55-709. III. Bibliography and Summary of Fault Location Methods, AIEE Working Group Report. General Systems Subcommittee

CP55-757. Practice of Fault Location in the Georgia Power Company System. *T. J. Allen*, Georgia Power Company

CP.* Practice of Fault Location in the Boston Edison Company. *D. F. Tulloch*, Boston Edison Company

CP.* Fault Location Methods. *R. F. Stevens, T. W. Stringfield, L. R. Spaulding*, Bonneville Power Administration

9:00 a.m. D-C Machines

CP55-725. Design Factors Affecting the Electromechanical Time Constant of Ward-Leonard Transmission with Inertia Load. *B. B. Young*, The Franklin Institute

55-677. II. Dynamics of D-C Machine Systems. *M. Riaz*, Massachusetts Institute of Technology

CP55-727. New National Electrical Manufacturers Association Standards for D-C Motors and Generators. *J. F. Davis*, General Electric Company

9:00 a.m. Land Transportation

CP.* Detection and Significance of Flaws in Traction Gearing. *J. B. McPherson* and *Mr. Bruckwicki*, General Electric Company
CP.* Maintenance Inspection of Traction Motor Gears and Pinions. *M. C. Winstanley*, Westinghouse Electric Corporation
55-754. II. Automation for Gravity Freight Classification Yards. *A. V. Danburg*, General Railway Signal Company
CP.* High Potential D-C Testing of Insulation. *M. C. DuBois*, DuBois Engineering and Manufacturing Company

9:00 a.m. Closed Circuit Television I

55-687. I. Developments in Closed Circuit Television. *M. H. Kraus*, Jerrold Electronics Corporation

CP.* The Application of Wired Television to Augment and Extend Human Vision. *John Day*, Kay Laboratories

CP.* Color Television in Medical Education. *Michael Klein*, University of Kansas Medical Center

CP.* Closed Circuit Television in the Bell System. *C. A. Bartlett*, American Telephone and Telegraph Company

2:00 p.m. Transmission and Distribution

55-710. III. Report on the Operation of Switched Capacitors. AIEE Capacitor Subcommittee

CP55-711. D-C Circuit Gives Easy Method of Determining Value of Capacitors in Reducing I^2R Losses. *R. A. Schmidt*, General Electric Company

55-712. III. Insulation Characteristics of Wood and Suspension Insulators in Series. *J. M. Clayton, D. F. Shankle*, Westinghouse Electric Corporation

55-713. III. Efficiency of Grounding Grids with Nonuniform Soil. *J. Zaborszky*, University of Missouri

CP55-756. The Arresters Without Power Follow Current—Operating Expense and Design Features. *C. L. Stroup, A. C. Westrom*, and *Alex Vitkus*, Hubbard and Company

2:00 p.m. Single-Phase Machines

55-728. III. Developing Iron Loss Curves for Small Motors from Motor Tests. *V. C. Shanaman*, Westinghouse Electric Corporation

55-729. III. Single-Phase Induction Motor Noise Due to Dissymmetry Harmonics. *D. F. Muster, G. L. Wolfert*, General Electric Company

55-684. III. Equivalent Circuits for Single-Phase Motors. *G. R. Slemon*, University of Toronto

55-730. III. Design Principles of Flux-Switch Alternators. *S. S. Rauch*, University of California; *L. J. Johnson*, Hufford Machine Works

55-108. III. Metadyne Transients. *K. A. Fegley*, University of Pennsylvania. Re-presented for discussion

2:00 p.m. Closed Circuit Television II

CP.* The Use of Television by the Biological Research Organization—Pilot Study. *M. C. Brown*, National Institute of Health

CP.* Closed Circuit Television at the State University of Iowa. *C. H. Menzer*, State University of Iowa

CP.* High Intensity Color Television for Very Large Screen Projection. *C. L. Ellis*, General Electric Company

2:00 p.m. Industrial Power Systems and Chemical Industry

CP55-688. Maintenance Problems of Electric Equipment Which Affect Design Considerations. *H. R. Walker*, The Dow Chemical Company

CP55-672. A Unique Industrial Distribution System. *Lee Dolkart*, Commercial Light Company

CP55-753. Modernization and Extension of Electrical Facilities at A Heavy Equipment Industrial Plant. *F. H. Carlton*, Sargent and Lundy; *A. Esty*, Allis-Chalmers Manufacturing Company

55-674. II. Problems Associated with the Development of a Power System for a Manufacturing Plant. *W. C. Heinz*, General Electric Company

55-689. II. System Neutral Grounding for Chemical Plant Power Systems. *D. S. Brereton, H. N. Hickok*, General Electric Company. Re-presented for discussion

55-690. II. Surge Protection on Industrial Systems. *C. L. Wagner*, Westinghouse Electric Corporation. Re-presented for discussion

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CP.*Unnumbered papers which may be available at and after the meeting if supplied by the authors. Publication by the Institute is not presently contemplated.

†Note: The AIEE *Transactions* papers will be printed in the bimonthly publications as follows: I Communication and Electronics, II Applications and Industry, III Power Apparatus and Systems.

Wednesday, October 5

9:00 a.m. New Developments in the Design of Digital Computers

CP55-742. The Wisconsin Integrally Synchronized Computer—A University Research Project. *J. L. Asmuth, C. H. Davidson, J. B. Miller, D. S. Noble, A. K. Scidmore,* University of Wisconsin

CP55-735. Arithmetic Design for a Transistorised Digital Computer. *R. A. Isaacs, J. L. Maddox,* Philco Corporation

55-719. I. The Design of the International Business Machine Type 702 System. *C. J. Bashe, P. W. Jackson, H. A. Mussell, W. D. Winger,* International Business Machines Corporation

CP55-736. The Interconnection of Two Digital Computers. *M. E. Stevens,* National Bureau of Standards

9:00 a.m. Insulated Conductors

55-691. III. Aluminum Sheathed Control Cable. *E. E. McIlvein,* The Okonite Company

55-692. III. Research on the Electric Breakdown of Fully Impregnated Paper Insulation for High-Voltage Cables. *P. G. Priaroggia, G. Palandri, A. Pirelli,* Milan, Italy

55-679. III. Characteristics of Single-Conductor Electric Cable at High Frequency. *J. T. Sabol,* Ohio Crankshaft Company

9:00 a.m. Switchgear

55-722. III. A New High-Capacity Anode Air Circuit Breaker. *S. A. Bottinari, J. H. Sprow,* Westinghouse Electric Corporation

CP55-721. A New 5-Kv 50,000-Kva De-Ion Air Circuit Breaker. *Russell Frink, J. M. Kovlovic,* Westinghouse Electric Corporation

CP.* New High-Capacity Service Entrance Protector for Industrial and Commercial Buildings. *L. L. Baird, V. N. Stewart,* General Electric Company

9:00 a.m. System Engineering

55-720. III. A New Method of Determining Constants for the General Transmission Loss Equation. *E. D. Early,* Southern Services, Inc.; *R. E. Watson,* Leeds and Northrup Company

CP.* General Circuit Theorems of Power Flow in Linear Networks. *J. F. Calvert, T. W. Su,* University of Pittsburgh

55-743. III. Two Large Electric Arc Furnaces—Electrical Characteristics and Corrective Equipment. *S. W. Luther, J. D. Ghuiquiere, C. E. Quick,* Detroit Edison Company

CP.* Guide for Application of Arc Furnaces on Power Systems. Preliminary Report by Working Group on Arc Furnaces

9:00 a.m. Telegraph Systems

55-175. I. A Polar Relay Using Momentum Transfer. *H. L. Garbarino, K. E. Bisshopp,* Armour Research Foundation of Illinois Institute of Technology. Represented for discussion

55-734. I. An Envelope Delay Measuring Instrument in the Audio-Frequency Range. *W. D. Cannon,* Western Union Telegraph Company

CP.* A New 18-Inch-Wide Continuous Web Facsimile Recorder. *A. G. Cooley,* Times Facsimile Corporation

CP.* Applications of a Frequency Shift Carrier Telegraph System in the Telephone Plant. *C. W. Smith,* American Telephone and Telegraph Company

CP.* A New Semiautomatic Teletypewriter Message-Relaying System. *R. J. Anspach, P. A. Tamasi, J. T. Neiswinter,* American Telephone and Telegraph Company

2:00 p.m. Insulated Conductors

55-678. III. Some Performance Characteristics of High-Voltage Rubber-Insulated Cables. *S. J. Rosch,* Anaconda Wire and Cable Company

55-668. III. Design and Evaluation of Butyl Rubber Insulated Power Cable. *J. C. Carroll, A. R. Lee, R. B. McKinley,* General Electric Company

55-693. III. Modern High-Voltage Rubber Insulations. *W. H. Couch, G. H. Hunt, N. D. Kenney, P. H. Ware,* Simplex Wire and Cable Company

2:00 p.m. System Engineering and Computers

CP55-744. Use of Digital Computers by Ontario Hydro-Electric Power Commission in System Engineering Problems. *L. J. Lacey, P. L. Dandeno,* Hydro-Electric Power Commission of Ontario

55-680. III. Digital Calculation of Network Impedances. *A. F. Glimn, R. Habermann, Jr., J. M. Henderson, L. K. Kirchmayer,* General Electric Company

CP55-745. Digital Load Flow Studies for Loss Allocation. *L. A. Dunstan,* Bonneville Power Administration

2:00 p.m. Improved Utilization of Engineers and Technicians

CP.* The Technician—His Training and His Role in Industry. *E. A. Williford, W. W. Wood,* Link Aviation

CP.* The Graduate Engineer—His Training and His Full Utilization in Industry. *S. B. Ingram,* Bell Telephone Laboratories

CP.* Optimum Utilization of Engineers and Technicians—The Management Problem. *J. N. Stanbery,* Illinois Bell Telephone Company

CP.* Case Histories of Effective Utilization. *J. N. Stanbery,* Illinois Bell Telephone Company

2:00 p.m. Wire Communications

55-683. I. Combined Operation of 24-Channel Cable Carrier and 12-Channel Open-Wire Carrier Systems. *G. W. Searle* (deceased), *R. A. Schaefer,* Wisconsin Telephone Company

55-682. I. A Pole-Mounted A-C Operated Repeater for 12-Channel Open-Wire Carrier System. *G. W. Searle* (deceased), *R. A. Schaefer,* Wisconsin Telephone Company

CP55-758. Local Television Facilities and Their Performance. *J. H. Ennenbach,* Illinois Bell Telephone Company

CP55-759. Video Frequency Attenuation Equalizers. *H. R. Stevens,* Illinois Bell Telephone Company

CP.* Developments in Communications in the Lower St. Lawrence Valley. *F. C. Dosk,* Quebec Telephone Corporation

Thursday, October 6

9:00 a.m. System Engineering

55-673. III. Principles and Practices of Modern System Planning. *A. P. Fugill,* Detroit Edison Company

55-746. III. Rural Electric System Planning. *J. H. Rixse, Jr.,* Rural Electrification Administration

55-669. III. General Study of Area Supply Methods. *J. A. Casazza,* Public Service Electric and Gas Company; *J. R. Rankin,* Rutgers University

CP55-747. System Planning for Reinforcement of the Iowa Division Union Electric Power Company. *A. A. Musler, C. C. Marxer,* Union Electric Company of Missouri; *D. P. Ayers, J. C. Endahl,* Sverdrup and Parcel, Inc.

CP55-748. An Approach to System Planning. *W. D. Johnson,* Illinois Power Company

9:00 a.m. Induction Motor Noise Symposium

55-724. III. Sonance Design for Large Induction Motors. *R. L. Wall,* General Electric Company

55-725. III. Apparatus Noise Measurement. *R. J. Wells,* General Electric Company

55-726. III. Predetermination of Sound Pressure Levels of Magnetic Noise of Polyphase Induction Motors. *E. Erdelyi,* Syracuse University

55-731. III. Measurement of Resistance of Energized A-C Motor Windings. *K. J. Waldschmidt,* A. O. Smith Corporation

9:00 a.m. Electric Storage Batteries

CP.* Nickel Cadmium Batteries in Industrial Service. *O. S. Sandburg,* Nife, Inc.

CP.* Internal Resistance Short-Circuit Current and Other Lead Acid Battery Characteristics. *E. A. Hoxie,* The Electric Storage Battery Company

CP.* Motor General Battery Charging. *J. J. Unger,* Electric Products Company

CP.* Metallic Rectifier Battery Charging.

Future AIEE Meetings

Petroleum Technical Conference
Shamrock Hotel, Houston, Tex.
September 12–14, 1955
(*Final date for submitting papers—closed*)

AIEE-ISA Instrument Conference
Shrine Auditorium, Los Angeles, Calif.
September 12–16, 1955
(*Final date for submitting papers—closed*)

AIEE-IRE Industrial Electronics Conference
Rackham Memorial Auditorium, Detroit, Mich.
September 28–29, 1955
(*Final date for submitting papers—closed*)

1955 Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 3–7, 1955
(*Final dates for TP*—closed, CP†—closed*)

Motor Application and Problems in Heating and Cooling Conference
St. Louis, Mo.
October 19–20, 1955
(*Final date for submitting papers—closed*)

Aircraft Electrical Equipment Conference
Hollywood Roosevelt Hotel
Los Angeles, Calif.
October 25–27, 1955
(*Final date for TP—closed, CP—closed*)

Middle Atlantic Textile Conference
North Carolina State College, Raleigh, N. C.
November 3–4, 1955
(*Final date for submitting papers—closed*)

AIEE-IRE-ACM Eastern Computer Conference
Hotel Statler, Boston, Mass.
November 7–9, 1955
(*Final date for submitting papers—closed*)

Electrical Techniques in Medicine and Biology Conference
Shoreham Hotel, Washington, D. C.
November 14–16, 1955
(*Final date for submitting papers—closed*)

EJC-AIEE Nuclear Engineering and Science Congress
Cleveland, Ohio
December 12–16, 1955
(*Final date for submitting papers—September 12*)

Winter General Meeting
Hotel Statler, New York, N. Y.
January 30–February 3, 1956
(*Final date for TP—Oct. 20, CP—Nov. 30*)

South West District Meeting
Dallas, Tex.
April 2–4, 1956
(*Final date for TP—January 3, DP‡—February 2*)

*TP—Transaction paper
†CP—Conference papers
‡DP—District papers

9:30 a.m. Effects of Radiation and Arcs on Dielectrics

CP.* A General Survey and Some Experimental Work on the Radiation Effect on High Polymers. *K. H. Sun, W. R. Thomas*, Westinghouse Electric Corporation

CP.* The Generation of High-Energy Electrons for Industrial Processing. *J. W. Ranfil*, General Electric Company

55-741. I. The Effects of High-Energy Gamma Radiation on Dielectric Solids. *P. H. Klein, C. Maunal*, General Electric Company

55-694. I. The Effect of Reactor Irradiation on Electrical Insulation. *J. C. Pigg, C. D. Bopp, O. Sisman*, Oak Ridge National Laboratory; *C. C. Robinson*, Wright Air Development Center

2:00 p.m. Power Generation

55-681. III. Economic Selection of Auxiliary Drive Motors in Power Plants. *E. T. B. Gross, V. F. Bobrowicz*, Illinois Institute of Technology

CP55-697. Auxiliary Transfer Scheme at Eastlake Proved by Operation. *C. F. Paulus, J. P. Fitzgerald*, Cleveland Electric Illuminating Company

CP55-760. Integrated Steam Station Protection. Working Group on Steam Station Protection

55-749. I. Operation of a Nuclear Power Plant on an Integrated Electric System. *N. E. Wilson*, Westinghouse Electric Corporation. Re-presented for discussion

2:00 p.m. Induction Motors

55-676. III. Double Energy Conversion in an Air Gap—A Novel Asynchronous Frequency Changer. *W. La Pierre, J. Y. Lowis*, Columbia University

55-675. III. Equivalent Circuit for the Concatenation of Induction Motors. *Y. H. Ku*, University of Pennsylvania

55-732. III. Ten-Part Winding Arrangements in Sample 4-Pole Induction Motor. *J. J. Courtin*, Westinghouse Electric Corporation

2:00 p.m. Carrier Current and Relaying

55-695. III. Future Application Needs for Carrier Pilot Relaying. *T. A. Cramer, F. C. Kringe*, General Electric Company

CP.* Frequency Shift Carrier for Distance Relaying. *H. W. Lensner*, Westinghouse Electric Corporation

CP.* Standards for Carrier Radiation. Project Subcommittee No. 8 of the Committee on Carrier Current

55-698. III. Power Line Carrier Coupling: An Analysis. *M. G. Birnhoff*, Los Angeles, Calif.

2:00 p.m. Arc-Resistant Dielectric Materials

CP55-699. Nontracking Organic Insulations. *R. S. Norman, R. A. Pfuntner, A. A. Kessel*, General Electric Company

CP55-755. Arc-Resistant Molding Materials and Finishes. *R. F. Sterling*, Westinghouse Electric Corporation

Friday, October 7

9:00 a.m. Radio Communication Systems

CP55-750. I. Presentation of Data on Broadband and Pulse Transformer Cores. *P. R. Gillette, K. Oshima, K. W. Henderson, R. M. Rowe*, Stanford Research Institute

CP.* A Simplified Approach to a 960 Mc Multichannel Radio System. *Curt Schultz*, Motorola Mobile Systems Engineering

CP.* A New Broad Band Microwave Antenna System. *A. S. May, R. W. Friis*, Bell Telephone Laboratories, Inc.

CP55-751. I. VHF Radio Link Between Puerto Rico and the Virgin Islands. *Roger McSweeney*, American Cable Corporation. Re-presented for discussion

CP55-752. I. The Seattle Victoria Radio System. *R. E. Kistler*, The Pacific Telephone and Telegraph Company. Re-presented for discussion

9:00 a.m. Motor Protection Symposium

CP55-761. Motor Temperature Characteristics. *J. F. Heidbreder*, Westinghouse Electric Corporation

CP.* Squirrel-Cage Motor Characteristics Useful in Setting Protective Devices. *F. R. Kerr*, Westinghouse Electric Corporation

CP.* Factors Influencing the Starting Duty of Large Induction Motors. *V. J. Picozzi*, General Electric Company

CP55-733. Advancements in Synchronous Motor Control and Protection. *John Baude*, Allis-Chalmers Manufacturing Company

9:00 a.m. Transformers

55-714. III. Transformer Temperatures on Short Circuit. *W. C. Sealey*, Allis-Chalmers Manufacturing Company

55-671. III. Sequence Impedances of Symmetrical 3-Phase Transformer Connections. *B. A. Cogbill*, General Electric Company

CP.* The Rigorous Solution of a Field Problem by Means of the Card Programmed Calculator. *L. Rabiss, J. R. Faillace*, General Electric Company

55-686. III. Experiences with the Use of Aluminum in Windings for Dry-Type Power Transformers. *E. W. Tipton*, Westinghouse Electric Corporation. Re-presented for discussion

9:00 a.m. Feedback Control Systems

55-700. II. Simple Analytic Method to Obtain Transient Performance from Open Loop Parameters of Linear Feedback Systems. *M. E. Clynes*, Bogue Electric Manufacturing Company

55-701. II. Estimating Transient Responses from Open-Loop Frequency Responses. *G. A. Biernson*, Massachusetts Institute of Technology

55-670. II. Quasi-Linearization Techniques for Transient Study of Nonlinear Feedback-Control Systems. *Kan Chen*, Westinghouse Electric Corporation

CP.* New General Stability Criterion for Servomechanisms (and Other Feedback Systems) With Time-Lag. *N. H. Chokzy*, The Johns Hopkins University; *T. J. Higgins*, University of Wisconsin

2:00 p.m. Rotating Machinery and Relays

CP55-696. Problems in Medium-Size-Motor Protection. *O. A. Lentz, T. Nitzsink*, Commonwealth Associates, Inc.

CP.* Problems of Applying Thermal Protection to Motors. *J. M. Bisbee*, Consolidated Edison Company of New York, Inc.

CP.* Motor Protection for Steam Power Stations with 4-Kv Grounded Neutral Systems. *W. F. Neff*, Ohio Valley Electric Corporation; *S. H. Horowitz*, American Gas and Electric Service Corporation; *R. B. Squires*, Westinghouse Electric Corporation

CP.* Protecting Motors with Low-Voltage Air Circuit Breaker Series Trips. *F. P. Brightman, P. J. Reifschneider*, General Electric Company

2:00 p.m. Transformers

55-715. III. The Application of a New Nontracking Butyl to High-Voltage Instrument Transformers. *R. A. Pfuntner, R. S. Norman, B. W. Wilterdink*, General Electric Company

CP55-716. Recent European Developments in Current and Potential Transformer Designs. *H. H. Schwager*, Schwager-Wood Corporation

55-717. III. Controls for Step Voltage Regulators. *T. C. Lennox*, General Electric Company

55-718. III. Contact Life of Voltage-Regulating Relays. *C. W. Schoendube, R. L. Elliott*, General Electric Company

2:00 p.m. Feedback Control Systems

55-703. II. Feedback in Contouring Control Systems. *F. J. Ellert*, General Electric Company

55-702. II. An Analysis and Analogue Computer Study of a Force-Reflecting Positional Servomechanism. *M. G. Spooner*, University of Wisconsin; *C. H. Weaver*, University of Tennessee

CP55-704. Transfer Function and Parameter Evaluation for D-C Servomotors. *G. J. Thaler, W. A. Stein*, U. S. Naval Postgraduate School

55-685. II. Short-Time Memory Devices in Closed-Loop Systems—Steady-State Response. *T. W. Sze, J. F. Calvert*, University of Pittsburgh. Re-presented for discussion

2:00 p.m.—Communication Switching Systems

CP55-762. Roll Welding Precious Metals for Telephone Contacts. *A. L. Quinlan*, Western Electric Company

CP55-763. Development of a Wire Contact Relay. *R. E. Markle*, International Business Machines Corporation

CP.* New Developments in Wire Spring Relays. *H. M. Knapp*, Bell Telephone Laboratories, Inc.

CP.* Dry Reed Switches and Relays. *O. M. Hovgaard, G. E. Perreault*, Bell Telephone Laboratories, Inc.

(*Continued from page 817*)

of plans to make inspection trips. Transportation to the Will County Station will be furnished at no charge by the Commonwealth Edison Company, and transportation to the electromotive plant of General Motors also will be furnished at no charge by the company's Electro-Motive Division. The Prudential Building is within easy walking distance of the hotel. Bus fees for other trips will be $2.00 each, except for the Museum of Science and Industry which will be $1.50 each. Tickets will be held in members' names at the trips registration desk for pickup during the convention. Send trip registrations and fees to E. B. Josler, Jr., The Okonite Company, 6045 South Knox Avenue, Chicago 29, Ill.

Ford Aircraft Engine Division, Thursday, October 6, 8:30 a.m. This plant is known as United States Air Force Plant no. 39. It is the largest government-owned manufacturing facility in the country. The property includes 476 acres of land and 19 major buildings with 6½-million square feet of floor space. The engine plant, which is the largest building, has approximately 4½-million square feet of floor area and is the largest single-story manufacturing building known to exist—87 acres under one roof with more than 6,500 machine tools.

Standard Oil Refinery, Wednesday, October 5, all day. (Luncheon will be provided by the Standard Oil Company.) The largest oil refinery in the Midwest, the Whiting Refinery of the Standard Oil Company of Indiana, is a landmark in the world-famous Calumet industrial district. The refinery, begun in 1889, is now equipped to process an annual average of 210,000 barrels per day of crude oil. The daily production of gasoline is $3^1/_2$ billion gallons per year.

The Whiting Refinery generates and distributes all of the power required for its own operation. There is no connection with a utility company. The total generating capacity is 64,000 kw. Power is generated in two stations. Steam is generated at pressures of 1,400 and 400 psi to supply turbine-generators and process.

The electric distribution system comprises three interconnected systems with respective voltages of 13,200, 4,160, and 2,400. The lower voltage systems are radial and the 13,200-volt system is a spot network system. The refinery has one of the largest independent local telephone systems (1,500 telephones) in the Midwest. There is a 2-way radio installation so that all mobile equipment can be contacted immediately.

McCook Plant of Reynolds Metals Company. Thursday, October 6, 1:30 p.m. The McCook Plant was built for the government during the second world war. It was leased

to Reynolds in 1946 and was purchased in 1949. It has facilities for remelting and alloying aluminum, a large hot mill, a cold mill, and associated equipment. This plant has produced more aluminum sheet in a day than any similar plant in the world.

The original cost of the McCook plant was $43,000,000. It has 2,344,000 square feet of floor space and there are 55 acres of the plant under roof. There are 122 furnaces in service, heated by electricity, oil, coal, and gas. Many electric motors are in operation, some rated as high as 5,000 hp. A special 138,000-volt power line brings electricity into the McCook substation which distributes power throughout the plant. Included among the 36 buildings are a 10,000-square-foot cafeteria, locker rooms, a 2-story office building, and a first aid station.

The McCook boiler house produces 40,000 pounds of steam per hour at 150 psi.

Will County Station. Wednesday, October 5, 1:00 p.m. The Will County station of the Commonwealth Edison Company is the newest addition to the company's great power system serving northern Illinois. It was formally placed in operation in March of this year and is the 12th large generating plant to become part of the Commonwealth Edison System.

Will County station has been under construction for more than 3 years. The initial installation consists of a 160,000-kw generating unit, but the installation of a second machine of the same size is being completed and is expected to be in operation at the time of the Fall Meeting. A third unit of 250,000-kw capacity is scheduled for completion in 1957.

The station is located on a 216-acre tract on the Chicago Sanitary Ship Canal near Lemont, Ill. This new station incorporates all the latest improvements in electrical generating station construction and operation. A coal-burning plant, it will require less than 1 pound of Illinois coal per kilowatt of electricity. This compares with $1^1/_2$ pounds per kilowatt-hour in some older stations and an average of 1.23 pound per kilowatt-hour for the Commonwealth Edison system in 1954. The boilers for each of the two 160,000-kw units will burn about 1,600 tons of coal in a normal day's operation. Will County brings the Edison system's installed capacity to 3,582,000 kw.

General Motors Corporation's Electromotive Plant. Tuesday, October 4, 1:30 p.m. Since the first diesel-powered streamlined train in the United States made its initial run in 1934, the Electro-Motive Division of General Motors has devoted its manufacturing facilities and engineering abilities to the mass production of diesel-powered mobile electric generating plants—diesel-electric locomotives.

More than 15,000 locomotives have been built and placed in service since the first was produced in the LaGrange plant in 1936. This is the only plant building all major components of such locomotives—diesel engines, electric generators, traction motors, car bodies, and trucks. At the present time, in addition to locomotive production, this plant is building the new Electro-Mobile generating units. These are completely diesel-powered electric generators designed especially to meet fringe area electric power generating requirements. These units are made in four capacities: 350, 500, 750, and 1,000 kw. They are mounted either on automobile trucks, on railroad flat cars, or installed on steel bases for permanent or semipermanent locations. The units are completely automatic both as to starting, synchronizing, and operation. Visitors to the electromotive plant will see the production of all the equipment that goes into these units.

Rauland Corporation. Tuesday, October 4, 1:30 p.m. The Rauland Corporation is of interest in that it has facilities for the mass production of television tubes and advanced electronic equipment.

Museum of Science and Industry. Thursday, October 6, 10:30 a.m. This is a trip being planned by the ladies and will be of great interest to every engineer. This institution, founded by Julius Rosenwald, occupies the reconstructed Fine Arts Building of the World's Columbian Exposition of 1893. The structure is a fine example of classic architecture. With a total floor area of some 14 acres it contains exhibits of scientific and industrial progress, many in full operation. These are arranged by subject into sections, such as "fuels and metals." Each section is grouped into sequences, often tracing an idea from its invention to its mass production.

Prudential Building. Tuesday, October 4, 8:30 a.m., 9:30 a.m., or 10:30 a.m. The Prudential building is Chicago's newest office building. This $40,000,000 structure is, perhaps, the most modern office building in the world. It has the highest electrical design load of any building in the United States, the fastest high-rise elevators in the world, and also the highest intensity lighting.

Registration

Members can simplify registration procedure by returning advance registration cards promptly which will save time in completing details upon arrival at the hotel. The registration desk at the hotel will be open Sunday afternoon, October 2, and from 8 a.m. to 4 p.m. daily thereafter during the convention. The registration fee will be $3.00 for members and $5.00 for nonmembers. No fee will be required for immediate families of members or for Student members.

Committee

The members of the 1955 Fall General Meeting Committee are: General Chairman Francis A. Cox; Vice-Chairman William M. Balienger; Secretary Howard R. Stevens; Treasurer Richard W. Jones; G. Leslie Welch, hotel arrangements; Frank M. Scott, finance and budget; Robert M. Bergslien, technical program; George E. Buchanan, registration; Donald M. Pearcy, trips-transportation; Merlin J. Adams, dinner-dance; Edward H. Finch, smoker; Foster A. Larson, entertainment; Michael J. O'Laughlin, sale of papers; Mrs. Robert B. Gear, ladies activities; Eldridge H. McNeill, hospitality; Edwin R. Whitehead, general session; Andrew W. Kramer, publicity.

Report on the Student Branches Committee Conference Held at Summer General Meeting

IN THE MEETING of the Student Branches Committee, criteria for establishment and maintenance of Affiliate Branches were considered. Drafts of application forms for Student Branches or Affiliate Branches were submitted together with a proposed model constitution for AIEE Affiliate Branches which had been prepared by a subcommittee. The completed applications will be reviewed by the Vice-President and the Chairman of the District Committee on Student Activities and, if satisfactory, will be forwarded to the Committee on Student Branches for action. If approved, the applications will be forwarded to the Secretary for approval by the Board of Directors.

President-Elect M. D. Hooven outlined the work of accreditation as done by Engineers Council for Professional Development (ECPD). The matter of Affiliate Branches was taken up at an ECPD Executive Committee Meeting which set up an ad hoc committee. The latter committee had asked Mr. Hooven to request AIEE to act slowly in the matter.

In connection with foreign Affiliate Branches and foreign Student Affiliate membership, the subcommittee did not wish to see Affiliate Branches established in any foreign countries because of differences in the educational systems and the higher costs of operation. It was therefore voted to recommend to the Secretary and the Board of Examiners that Student Affiliate enrollmen be limited to the 48 states, Washington, D. C., and Canada.

Industry Speaker Program

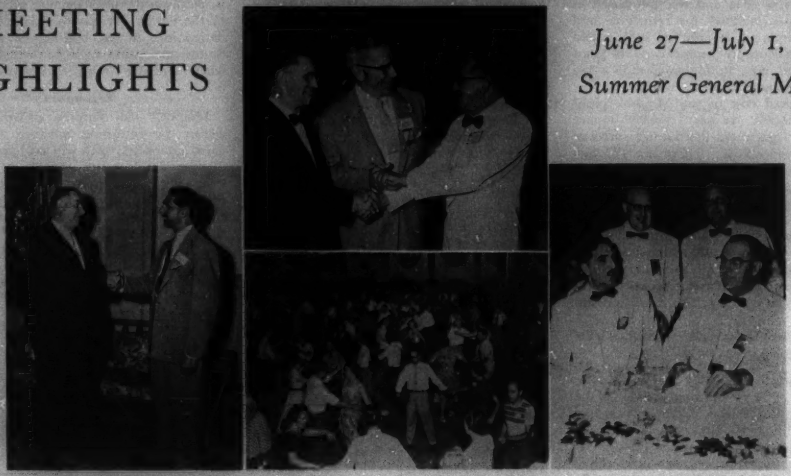
A report on the industry speaker program in three parts was submitted by J. L. Callahan, chairman of the subcommittee. One part summarized up-to-date information from companies participating in the program. Another was a letter to the industry representatives calling their attention to information received from the branch counselors and the third part summarized information received from the branch counselors regarding organizations offering speaker assistance. Industry speakers have been reaching certain branches but in some instances, especially in the case of remotely located schools, offers have not been forthcoming. The report and recommendations were accepted by the Student Branches Committee and it was voted that the counselors be informed of this program and the responsibility for carrying it out.

Student Branch Manual

A report was submitted by J. W. Rittenhouse which outlined revisions for the Student Branch Manual to bring it up-to-date. The report was approved and the revision is to be ready early this month. Four copies will be sent to counselors and additional copies will be supplied as requested.

MEETING HIGHLIGHTS

June 27—July 1, 1955
Summer General Meeting



NEWLY-ELECTED AIEE PRESIDENT (center picture, right) M. D. Hooven, is congratulated by J. D. Tebo (left), director of the Institute, and W. J. Barratt (center), treasurer. Picture at left shows J. Lynd of the Hawaiian Section (left) being welcomed by M. A. Princi, general chairman of the meeting committee. Mr. Lynd brought small orchids with him for the ladies. Bottom center scene was taken at the barn dance held the first evening of the meeting. Pictured at right are: (sitting, left to right) General Meeting Chairman M. A. Princi; Immediate Past President A. C. Monteith, and (standing, left to right) E. K. Rohr, chairman, entertainment and banquet committee; Dr. C. G. Suits, who delivered the main address at the banquet on Wednesday evening (see pages 753–58 for address).

Sound-Slide Program

A report on the sound-slide program, a 35-minute presentation, with slides and a tape recording prepared by G. W. Bower, chairman of the subcommittee, was presented by W. L. Morton, who urged cooperation of the Sections in this program.

Publications for Students

In connection with AIEE publications and folders for students, the suggestion was made that the covers should illustrate electronic equipment, television antennas, and power stations so that the Institute would not be considered as a power organization only. The view was expressed that a separate student publication would detract from *Electrical Engineering*. A recent survey, conducted by the Institute of Radio Engineers, indicated that views had been expressed by everyone except students. Articles can be written by students who have been in industry about a year as indicating to graduates what to expect. The student posters were considered effective and the committee decided to carry on with this form of publicity.

District Prize Awards

It was reported that Districts 1 and 5 always have provided extra prizes for students and the view was expressed that a trophy displayed in the schools could be valuable. Another suggestion was that a third prize consisting of honorable mention and a certificate, if the judges so recommend, should be added. District 4 favored the inclusion of second and third place prizes. In conclusion, Chairman R. F. Danner stated that many people believed the prize awards inadequate and that a subcommittee should be appointed to consider this matter and to make a study of the graduate student prize. With reference to the word, "originality," in the grading rules for student prize papers a new definition of the word was proposed by Professor E. L. Sitz, counselor of the Branch at Kansas State College, which was accepted and recommended to the Prize Awards Committee.

As the meeting concluded, Chairman Danner and Past-President Elgin B. Robertson (1953–54) were given a rousing vote of thanks for their student branch work.

Highlights of Technical Sessions at Summer General Meeting Reported

BECAUSE there were more than 50 technical sessions plus conferences in parallel during the five days of the Summer General Meeting, and because of the limited staff to cover the meeting, just a few of the highlights of the program follow.

Conference on Ethics

Among the more general types of sessions held was a conference on ethics sponsored by the Committee on Code of Principles of Professional Conduct, with P. L. Alger presiding. The first paper by Professor H. W. Bibber of Union College dealt with the teaching of ethics to engineering students. Professor Bibber analyzed why the teaching of this subject is difficult, the methods which might be employed—including the advantages of the "Case" method and ways in which the societies can aid the schools in teaching ethics. The second paper, presented by Charles T. Chave, was, "What Ethics?" This gave an interesting insight into the development of the Canons of Ethics by Engineers Council for Professional Development (ECPD) and pointed out that practices in different fields of the engineering profession—civil, mechanical, and electrical—were different. Specific cases of ethical dilemmas were illustrated. In conclusion the author urged support of the Argersinger Plan with publicity, discussion, and arguments about ethical dilemmas to get engineers to think along these lines with the hope that eventually many difficult questions will be resolved. The third paper on this subject, "The Philosophy of Codes of Ethics," by Professor L. L. Fuller of Harvard Law School considered the legal point of view. The belief was expressed that there was a parallel between the law and engineering professions.

Power Sessions

In several of the power generation, rotating machinery, and particularly in the transformer sessions, the important subject of functional testing of apparatus was extensively discussed. Much work yet remains to be done by the users and manufacturers of apparatus, but such experts as M. J. Vogel, G. L. Moses, and C. P. West, expressed gratification in their comments on the papers concerned with the development of uniform methods of functional evaluation of apparatus.

Television

One of the best received sessions was that devoted to color television. The opening paper by John Thorpe, American Telephone and Telegraph Company, considered the changes in telephone network facilities necessitated by color television within the past year. As the work was done on existing systems, it was necessary to consider the effects on monochrome transmission as well as the modifications necessary for color to assure optimum conditions for reception of both types of signals.

E. M. Gore, Radio Corporation of America, described the basic problems in film pickup for television broadcasting. Both 16-mm and 35-mm films are shown 24 frames per second and television operates at a rate of 30 frames or 60 fields per second. Hence a method of conversion, commonly called "3–2" mechanisms must be used or else a system of projection must be employed which transports the film at uniform velocity. When used with color film a "3–V" camera has proven satisfactory. This uses a 3–2 mechanism and three vidicon camera tubes.

"The Continuous Film Projector and Flying Spot Scanner for Television" was described by R. E. Putman, General Electric Company.

The final paper of the session, "A Color Projection Receiver," W. F. Bailey, R. P. Burr, and R. J. Keogh, Hazeltine Electronics Corporation, described a set which does not use the conventional color picture tube. Instead, three projector tubes are employed, one for each primary color, whose projected images are superimposed on a slanting mirror. From this, the color image is reflected to a viewing screen. The compactness of the optical system and projector tubes make this receiver comparable in size to a console television receiver and it was estimated that the price will be competitive.

Electronic Components

In the session on the reliability of electronic components, of which H. L. Flowers was the chairman, four conference papers, and two technical papers were presented.

In a conference paper by R. S. Schultz and W. R. Waltz of the Vitro Corporation of America, Mr. Schultz described a long-range standardization project undertaken for the Navy. More than 100 pieces of electronic equipment have been analyzed so that advantage can be taken of subassemblies which can be made up into components for functional use; i.e., by circuits as amplifiers, wave-shaping, gating, etc. in radar sets. This can be further broken down into electrical functions; for example, the front end of a superheterodyne receiver into tuner, oscillator, mixer, etc. A study has been made where each of these are common to other sets, the data being recorded on edge-punched cards. It is the aim to reduce the number of subasssemblies so that more of one type can be used in different components.

A progress report on modular design of electronic equipments was made by J. G. Reid, Jr., R. L. Henry, and C. C. Rayburn, ACF Electronics.

Another paper which showed the trend toward simplification of circuitry and standardization was given by J. H. Muncy, National Bureau of Standards (NBS) describing that organizations preferred circuits program. Analyses have been made of military communication, radar and other electronic equipment in regard to similarity of design. An example was given of eight marker generator circuits which were practically identical and with very slight changes could have been reduced to one basic circuit. It is estimated that between 50 and 70 per cent of like electrical systems can be so reduced. The aim of the program is to have manufacturers' designers use basic circuitry with similar components and mechanical features to achieve greater reliability and reduced costs. The NBS will publish a series of pamphlets on different circuits before the end of the year.

In "Prediction of Electronic Reliability Based on Design Factors," V. Harris and M. M. Tall, Vitro Corp. of America, explained how their system functioned as it is on drawing-board design. Seventeen electronic sets were studied and analyses made of hundreds of Naval equipments failure reports. Detailed statistics were presented showing the failure rates of electronic tubes, capacitors, resistors, transformers, etc. and by applying certain fundamental principles to the design of apparatus it is felt that an improvement in reliability will be accomplished.

Rectifier Theory

Four conference papers were presented Friday morning in the session devoted to the theory of rectifiers. These papers dealt with germanium and silicon rectifiers—their characteristics, surface states, breakdowns, and designs.

One of the most interesting papers was a description of breakdown mechanisms by K. G. McKay, Bell Telephone Laboratories, and which was illustrated by slides made from photographs of the phenomena. The author presented two breakdown theories: internal field emission and "avalanche" breakdown. The latter is similar to a gas discharge. Measurements were made in both germanium and silicon.

AIEE Board of Directors Meet at Summer General Meeting, June 30

A REGULAR MEETING of the Board of Directors was held during the Summer meeting, June 30, at the Thomson Club in Nahant, Mass. Both Directors and Vice-Presidents elected to the 1955–1956 board were present. Also, the Committee on Planning and Co-ordination joined the Board for part of the afternoon session.

Admissions and Transfers

By admission or transfer, the Board approved the following additions to the several grades of membership: 18 Fellows, 212 Members, 792 Associate Members, 101 Affiliates, 678 Students, and 72 Student Affiliates.

Upon proposals, approved by the Board of Examiners, the Board voted to invite the following members to be transferred to the grade of Fellow:

Harry Barker, Partner, Barker and Wheeler, 11 Park Place, New York 7, N.Y.

Delmer Wallace Callander, Consultant, Canadian Westinghouse Company, Ltd., Hamilton, Ont., Canada

William David Cockrell, Electrical Engineer, Guided Missiles Department, Aeronautics and Ordnance Systems Division, General Electric Company, CAP 1, Schenectady 6, N.Y.

William David Coolidge, Consultant, General Electrical Research Laboratory, The Knolls, P. O. Box 1088, Schenectady, N.Y.

Fulton Cutting, Professor of Physics and Assistant to President, Stevens Institute of Technology, Hoboken, N.J.

Alan Graeme Darling, Retired from General Electric, General Consulting Engineering, 1445 Wendell Avenue, Schenectady 8, N.Y.

Rene Dupuis, Commissioner, Quebec Hydro Electric Commission, 107 Craig Street, West, Montreal, Que., Canada

Walter Burton Fisk, System Engineer, Consolidated Edison Company of New York Inc., 4 Irving Place, New York 3, N.Y.

Chester Irving Hendricks, Design Engineer, Texas Electric Service Company, P. O. Box 970, Fort Worth 1, Tex.

Ray Albert Larner, Meter and Relay Engineer, Texas Electric Service Company, P. O. Box 970, Fort Worth 1, Tex.

Russell McLeod Laurie, Manager, Western Region, Hydro Electric Power Commission of Ontario, 340 Wellington Street, London, Ont., Canada

Louis George Levoy, Power Systems Engineer, Industrial Engineering Section, General Electric Company 1 River Road, Schenectady 5, N.Y.

Gerhard Lionel Oscarson, Chief Application Engineer, Electric Machinery Manufacturing Company, 800 Central Ave., Minneapolis 13, Minn.

Carl Eugene Scholz, Vice-President, American Cable and Radio Corporation, Chief Engineer, Mackay Radio and Telegraph Company, Inc., and All America Cables and Radio, The Commercial Cable Company, 67 Broad Street, New York 4, N.Y.

Hubert Ryerson Sills, Supervisor, Design Engineering A-C Machines, Canadian General Electric Company Ltd., Park Street, Peterboro, Ont., Canada

George Oliphant Watson, Principal Electrical Engineer Surveyor, Lloyd's Register of Shipping, 71 Fenchurch Street, London, E.C. 3, England

Finances

Walter J. Barrett, Treasurer, summarized the status of the General Fund at the end of the fiscal year, April 30, 1955, in which $100,000 had been transferred from the Capital Reserve Fund to the General Fund. The balance in the General Fund, April 30, was $27,522.38. On a cash basis, expenses exceeded income by $81,187.97. The Auditor's Report (see page 739 of the August issue of *Electrical Engineering*) shows this deficit to be $106,050.15, on an accrual basis. As of May 31, 1955, the balance in the General Fund was $31,702.11.

The Finance Committee chairman, C. S. Purnell, reported disbursements from the General Fund as follows: April, 1955—$145,227.84 and May, 1955—$89,579.63.

General and District Meetings

L. F. Hickernell, chairman of the Committee on Planning and Co-ordination, reported on the schedule of General Meetings, showing that all such meetings are now settled 5 years in advance. District meetings are planned about 3 years in advance, and progress is being made towards extending that schedule further into the future. At this meeting of the Board the Summer General Meeting of 1961 was added to the list of approved future meetings. An invitation from the Ithaca Section and Cornell University to hold the 1961 meeting on the

Cornell campus, June 19–23, was accepted. See page 852 for a tabulation of future General and District meetings through 1961.

The Board also adopted "Policies on General and District Meetings" as proposed by the Planning and Co-ordination Committee. This is a brief guide for Section and District officers contemplating holding a General or District meeting in their territory. See page 851 for the full text.

Mr. Hickernell presented a new publication which he compiled showing graphically and tabularly the exact territory assigned to each of the 11 Districts and 109 Sections.

The Board approved a change in the name of District 3, which will now be known as "The Metropolitan New York District."

A preliminary report on the results of the 1955 Membership Opinion Poll, conducted by The Opinion Research Corporation, under the auspices of the Planning and Co-ordination Committee, was heard. Final results will be published for the membership when completed.

Sections

On recommendation of the Sections Committee, transmitted by the chairman, W. R. Hough, the Board took the following actions:

VOTED, that Section appropriations be paid semi-annually and not be reduced by any previous report of an unexpended balance in the Section Treasury.

VOTED, to approve the formation of the Maine Section as the 109th, including in its territory all of the State of Maine.

VOTED to approve the transfer of Morris and Titus Counties from the North Texas to the Shreveport Section.

Student Branches

As recommended by the Committee on Student Branches, of which R. F. Danner is chairman, the Board approved the formation of an Affiliate Student Branch at Gannon College in Erie, Pa. This is the fifth Affiliate Student Branch to be approved. See *Electrical Engineering*, June 1955, page 533 and this issue, page 826.

Vice-Presidential Duties

On recommendation of the Conference of Vice-Presidents and District Secretaries, which met June 27, 1955, the Board of Directors approved the following resolution superseding resolutions of April 27, 1950, and July 27, 1946, on the same subject.

RESOLVED: it is the sense of the Board of Directors that:

(*a*) Attendance of the President at General meetings, District meetings, meetings of the Engineers Joint Council, and other intersociety obligations should take preference over visits to Sections and Branches.

(*b*) The District Vice-President shall be made fully responsible for the visits to Sections, and Branches. It shall be the duty of the District Vice-President to receive all requests for visitations by Institute Officers and to co-ordinate these requests for all meetings in his area.

(*c*) It is essential to the growth and development of the Institute that an effective means of communication be established and maintained between the Board of Directors and the membership. The most effective means of accomplishing this objective is the personal visitation to the Sections and Branches by the District Vice-President.

(*d*) The Vice-President should endeavor to visit each Section and Branch in his District once each year.

(*e*) It is desirable that each visitation include an informal discussion with Section and Branch officers.

(*f*) The Vice-President may request the co-operation and assistance of the Directors in making such visitations.

(*g*) When the formal visits to Sections are made by either the District Vice-President or by some other officer, the same expense allowance will be paid by the Institute as if the visits were all made by the Vice-President.

(*h*) At each Summer Meeting, it shall be the duty of the Secretary of the Institute to call a special meeting of the holdover and incoming Vice-Presidents at which they shall be informed of their duties in co-ordinating the work in the Districts.

(*i*) This resolution shall supersede previous expressions of policy as embodied in resolutions of April 27, 1950, and July 27, 1946.

New Technical Committees

On recommendation of the Committee on Technical Operations, J. D. Tebo, chairman, the Board approved three new technical committees. To the Communications Division there is to be added the Committee on Communication Theory. The Science and Electronics Division will add the Committee on Dielectrics, and the Committee on Solid State Devices.

Engineers Joint Council

Walter B. Morton, AIEE representative on the Executive Committee on Engineers Joint Council (EJC), reported briefly on the following EJC projects: A new Committee on Nuclear Energy; A Long Range Planning Committee for EJC; progress towards unity and individual membership in EJC; plans for the 1956 EJC General Assembly; A report by the EJC–Engineers' Council for Professional Development Committee on the Practice of Engineering concerning corporation practice.

United Engineering Trustees

Noting the fact that the Five Societies had taken a variety of actions in response to the recommendations of the Committee of Five Presidents concerning a location for the Engineering Societies Building (See *Electrical Engineering*, June 1955, page 532), the Board appointed Elgin B. Robertson to negotiate with representatives from the other four societies. (Mr. Robertson was AIEE President during 1953–54.) He and the other representatives will work for a program acceptable to all five societies by which they will select a new building.

Management Survey

The Planning and Co-ordination Committee joined the Board of Directors during the afternoon session to hear an interim report on the study of the Institute's organization and financing which was authorized at the February 1955 meeting of the Board. A. J. Bergfeld gave a report for Stevenson, Jordan, and Harrison, Inc., management engineers, which had been engaged for this work.

The preliminary phases of the study were exploratory and covered publications and Section meetings. Mr. Bergfeld reported the findings in these fields and made some tentative recommendations which will be considered by the cognizant committees. He then outlined what his firm proposed to do if authorized to proceed to the completion of the study contemplated by the February action of the Board.

After general discussion, and with all present invited to join in the voting, the proposal to continue the study by Stevenson, Jordan and Harrison, was approved.

Future Board Meetings

The Board voted to hold its August 1955 meeting in Butte, Mont., during the 1955 Pacific General Meeting; its October meeting in Chicago, Ill., during the 1955 Fall General Meeting; and its Spring Meeting during the District 7 Meeting in Dallas, Tex. in April 1956.

Appointments

The Board approved appointments and elections to committees of the Institute for the administrative year 1955–1956, as given in detail on pages 837–50 of this issue of *Electrical Engineering*.

Three New Technical Committees Approved by AIEE Board of Directors

THE FORMATION OF THREE new AIEE technical committees was approved by the Board of Directors, at the June 30th meeting (complete board meeting report, pp. 823–24). One of these lies in the realm of the Communication Division, the new Committee on Communication Theory, and the other two in the Science and Electronics Division. These two are the Committee on Dielectrics and the Committee on Solid State Devices.

The Committee on Communication Theory will treat matters of principle and theory in the field of communications which do not fall within the scope of the other committees of the division. This includes:

1. Aspects of information theory of special interest in communication
2. The fundamental nature of and requirements for transmission of communication signals, including telephone, telegraph, television, telemetering, data transmission, remote control, etc.
3. Theory and comparative effectiveness of various modulation systems
4. Formulation of objectives, evaluation of performance, and methods of measurement
5. Relationship between the performance and reliability of communication systems and their important basic components, such as vacuum tubes, and transistors.

Chairman of this committee is L. G. Abraham of Bell Telephone Laboratories.

L. J. Berberich, Westinghouse Electric Corporation, will head the Committee on Dielectrics. This committee will not attempt to encroach on any existing apparatus insulation subcommittee, but will serve in the same field that the Subcommittee on Dielectrics has in the past, with a somewhat expanded scope and a co-ordinating function added. It will treat all matters relating to the theory and practice in the field of dielectrics and insulation except those related to applications involving specific apparatus. This includes the following:

1. Promotion of symposia on all aspects of the field of dielectrics ranging from theory to general applications with the purpose of serving the design and development engineers who must apply such information to practice

2. The treatment of various phases of the field of dielectrics, such as solids, liquids, and gases

3. Study of mechanism of deterioration of dielectrics in general, particularly as caused by heat and corona, and the evaluation of insulating materials in a broad way

4. Development and standardization of test methods for the thermal evaluation of insulating materials and simple combinations of materials, but not including insulation systems for specific apparatus

5. Co-ordination of the various activities in the field of dielectrics and insulation in the Institute through liaison members from the various apparatus insulation subcommittees

There are five subcommittees: Solid Dielectrics, Liquid Dielectrics, Gaseous Dielectrics, Thermal Evaluation of Dielectric Materials, and Effects of Corona on Dielectrics. The membership of the main committee includes liaison members from the various insulation subcommittees of the apparatus committees and the Transformer Committee, the Rotating Machinery Committee, the Insulated Conductors Committee, and the Instruments and Measurements Committee.

The liaison members are to make possible the co-ordination of the various insulation activities of the Institute and plan the various meeting programs so that there will be no conflicts. All matters dealing with applications of insulation to specific lines of apparatus, such as transformers, cables, rotating machinery, etc., are to be referred to the proper apparatus insulation subcommittee.

The new Committee on Solid State Devices will be headed by J. P. Jordan of the General Electric Company. The aim of the committee is to stimulate progress in electronics by recognizing the complementary character of recent developments in semiconductors, ferrites, ferroelectric dielectrics, and related fields. The responsibility of the committee is twofold:

1. To give an integrated treatment to these new fields in the dissemination of information by means of symposia and publications, and to bring together for mutual profit workers in these complementary fields so that advances, present needs, and future possibilities of each will be available to the others with greatest possible speed and in a language all such workers will appreciate

2. To improve communication between the various fields by mutually consistent standardization of definitions, nomenclature, symbols, operating characteristics, and test procedures

The scope of the committee is the treatment of all matters pertaining to solid state devices as applied to the electronics field. This includes the specific applications of ferrites, ferroelectric and nonlinear dielectrics, semiconductors, phosphor and photoconductive materials, but excludes such devices and circuit applications as covered by other committees, except by mutual agreement. The committee will attempt to bridge the gap between the research effort which concerns the Basic Sciences Committee and the use areas exemplified by the various specific end-product committees.

The subcommittees of this new committee are to be formed in parallel with corresponding subcommittees of the Basic Sciences Committee. The Solid State Devices subcommittees will deal primarily with devices and applications and those of the Basic Sciences Committee will deal with theories, basic properties, and general applications of materials.

It has been proposed that all subcommittees be made joint with a newly-formed Institute of Radio Engineers (IRE) committee (Solid State Devices) to avoid duplication and to utilize the best talents of the available experts. The two committees would remain separate entities although they would arrange to hold most meetings jointly. The joint subcommittees would operate with joint chairmen, one representing the AIEE, one the IRE. Those interested in contributing to this work may contact the chairman.

Section Delegates and Sections Committee Confer at Meeting Held June 28, 1955

THE NEW SECTIONS and Subsections organized since June 1954, were recognized at the Sections Committee and Section Delegates Conference, June 28. These new Sections are: St. Maurice Valley, Hawaiian, Iowa-Illinois, Lima, West Michigan, Savannah, Baton Rouge, and Johnstown. New Subsections are: Central Savannah River, Los Alamos–Santa Fe, Medford, Northwest Iowa, Quebec, and Riverside–San Bernardino.

Also Section growth awards were presented to (larger than average Sections): Los Angeles, Connecticut, New York, North Texas, and Pittsburgh; (smaller Sections) Jacksonville, Providence, Rock River Valley, Virginia, and Nebraska. Gavels were presented to these Sections by J. L. Fuller, Secretary, Sections Committee.

The purpose of the meeting, to provide a medium for exchange of information about Section activities, was explained by W. R. Hough, Chairman, Sections Committee. Some of the information exchanged at this particular meeting follows.

Student Branches

The work of the Student Branches Committee was outlined by 1954–55 Vice-President Walter B. Morton. He predicted that in the next 2 years good results will be seen. The appointment of Student Activities Committees in the Sections was advocated, as well as the holding of prize paper competitions, father and son dinners, and joint section and Branch meetings. These joint meetings have been very successful in some Sections.

Sections Operations Manual

A progress report on the development of a "Sections Operations Manual" was outlined by Director R. E. Kistler of the Sections Committee. The manual is to be of the loose-leaf type, illustrating Section organization and giving duties of each officer, as well as the operation of the Section. The back of the manual will be reserved for literature which can be replaced as revised. Criticism was invited with the suggestion that delegates write in comments, tear the manual apart, and put it together in the order they prefer.

Public Relations

The public relations field of activity was described by R. T. Ferris, Chairman, Public Relations Committee. Mr. Ferris explained that Fischer Black is increasing the scope of the Institute's publicity kit. He said, too, that in the Philadelphia area people are beginning to know what the engineer is and does.

A recording, "Meet the Engineer," highly successful in the Philadelphia area, was demonstrated by Thomas MacCauley. These scripts are available to any of the Sections at $5.00 per script from the Philadelphia Section by writing to Mr. MacCauley. He explained that if it can be proved to the radio station that this is a public service, the station will be glad to give time for the broadcasts. The purpose of the scripts is to acquaint the public with the value of the engineer and the work of the AIEE.

Transfers

Procedure in transfers to membership grade was discussed by E. P. Yerkes, Chairman, Transfers Committee. Transfers are important because it is to the advantage of each member to hold the highest grade of membership for which he is qualified. Applications are the only means by which the Board of Examiners can judge the qualifications of applicants. Therefore, they should be as complete as possible and care should be given to the selection of references. Transfers cannot be made automatic. They are the result of recognition of accomplishment. Whoever prepares the application should try to write a statement in 25 to 50 words illustrating why the career of the applicant is exceptional.

Report on Unity

Progress toward unity of the profession was reviewed by Past Vice-President Morton. He said that everybody wants unity and that many letters have been received. For example, when an announcement is made by the American Medical Association, he said, it is considered authentic and accepted by the public. The steps taken toward unity through Engineers Joint Council and the work of the Council were described. However, as now operated, without individual membership, the Council constitutes a federation of engineering societies. An AIEE plan for unity was presented, which will be published in a subsequent issue of *Electrical Engineering*.

Policies on General and District Meetings

Tentative policies on General and District meetings were presented by L. F. Hickernell, Chairman, Committee on Planning and Co-ordination. General and District meeting schedules should be planned at least 5 years

in advance to obtain adequate hotel accommodations and to effect planned rotation of locations. Hotel accommodations should be based upon estimated out-of-town attendance for the year in which the meeting will be held. Also, accommodations are to be made at hotels which do not charge for committee meeting space, delegate conference rooms, etc. Hotel managements, policies on location, and frequency of holding General and District meetings were also outlined. And, a set of curves was shown of the comparative growth of telephones, electric energy, AIEE membership, and a projected rate of growth in attendance of Winter and Summer meetings for the next 8–10 years. (See page 851 of this issue for further information about meeting policy.)

Los Angeles Section Operation

The operation of the Los Angeles Section from the time when three divisions were formed—power, electronics, and aircraft—was analyzed by G. T. Harness, Section chairman. He said that if Sections are to justify their existence, they must serve the membership as fully as possible. In an effort to extend such service, four new divisions—basic sciences, communications, management, and the young engineers' division—as well as the Riverside–San Bernardino Subsection, were added this year. The young engineers' division has been highly successful and fills an important need for engineers just after graduation. This group sets up its own programs. Subjects such as microwave transmission, instrumentation and rocketry, and economics have been presented so far. Professor Harness thought that the Los Angeles Section ought to have as many as 20 divisions. It is policy to start the divisions as committees. Also, the view was expressed that General meetings have become too general and the objective should be to provide meetings in which every member finds something of interest and takes an active part in the affairs.

President's Remarks

AIEE President Montieth commented on the inspiration obtained from the meeting and the need to recognize the changes taking place in the Institute from observing the Sections. New members of the Board of Directors were introduced and Mr. Montieth commented on the need of a better system of communication between Vice-Presidents, Sections, and the Board of Directors. It is expected that each Vice-President will visit each Section and Branch in his territory once a year, but the territory should be kept to a size whereby this can be done conveniently. Attention was drawn to the work of Engineers' Council for Professional Development (ECPD) and the fact that the ECPD is not well known by many members.

In conclusion, Mr. Montieth called attention to curves appearing on the back of the Board of Directors Report. These show that approximately half of the electrical engineering graduates from accredited colleges in the past 10 years have become members. He said that something must be done to increase this number.

Separate Conferences

In the afternoon, the conference was divided into two groups. Bradley Cozzens, Vice-Chairman (West), Sections Committee, presided over larger Sections, and Dixon Lewis, Vice-Chairman (East), Sections Committee, presided over smaller Sections. Means of increasing attendance, inspection trips, and the success of technical groups and management groups were discussed, as well as ways to nominate Section officers, the relief of the Section treasurer, and different ways to stimulate vocational guidance at the high school level. Other information exchanged concerned awards to Section officers and members such as certificates, past-chairmen's pins, recognition of Fellows, and the engineer of the year. After exchanging experiences, the groups reconvened in one conference.

Section Appropriations

In the light of the increase in dues Treasurer Walter J. Barrett explained why it would not be practical to increase Section appropriations. It would be improper, he said, to figure an increase of $5.00 over the whole range of membership, as the Institute would lose some members and the number which would be lost is unknown. Attention was also drawn to the recent deficit of $106,000. Although the net cost of publications had been reduced by $45,000 and there are budget forecasts that there might be a $43,000 surplus at the end of the year, it is questionable, because of increased activities, whether or not finances can be held at this level for the next 2 or 3 years.

Incoming President's Message

President-Elect Morris D. Hooven gave an inspiring talk to Section delegates from a background of much experience. The change in the Institute has been one of tremendous growth and the forecast of the Planning and Co-ordination Committee indicates a membership of 100,000 in not too many years. This increase in membership will give rise to special problems.

To see that young people are interested in science and engineering, beginning in the seventh and eighth grades, is a community responsibility, according to Mr. Hooven. The increase in the number of engineers per worker was in the order of 1 to 1,000 in the 1880's and in one of the aircraft companies the ratio now is 1 engineer to 25 workers. Census figures show that 1,100,000 persons reach the age of 18 each year, and other statistics indicate 16 per cent have the required mentality for higher education. Consequently, only 80,000 individuals per year are available for training in all the professions.

Attention was called to the establishment of ECPD and one of its original council members, the late Dr. William E. Wickenden. Mr. Hooven referred to the work of ECPD and the accreditation program handled by Dean Harold E. Hazen—student development, work with the young engineer, and the post baccalaureate training programs in Cincinnati, Ohio, and Detroit, Mich. In conclusion, AIEE's new President urged recruitment from the seventh or eighth grade to age 35. It is the responsibility of the engineers in the Sections, and in the communities, to interest young people in science and engineering through high school, in colleges, and in the profession.

Safety Activities

C. E. Ganther, Chairman of the Safety Committee, called for the help of the delegates to carry safety information to the communities. He referred to statistics on accidents and the number of fatalities in traffic and in the home. Accidents in industry are about 15,000 per year. If this is to be reduced 10 per cent, a good job will have to be done. In cases of electrical accidents, the chances of fatalities are much greater. A safety program in each Section each year was advocated and a guide for safety activities for Sections and Subsections was presented.

Membership

The chairman of the Membership Committee, W. E. Scholz, drew attention to figures in the Board of Directors' Report. Although student enrollment increased, the rate of growth is declining. He said that the Institute must look to sources other than students for increased growth. The Sections will have to work on this, he said, and appealed for help through the Section membership committee chairmen. He urged an early start by sending to Headquarters the name of the Section membership committee chairmen as soon as known.

Student Affiliates, Affiliate Branches Reported on by Student Branches Committee

AIEE HAS ESTABLISHED a new grade of student membership, "Student affiliate," and a new type of branch, the "Affiliate Branch" for newly established, and as yet unaccredited, 4-year engineering colleges. As reported in the June issue of *Electrical Engineering*, page 533, the AIEE Board of Directors amended the Bylaws and authorized the organization of four Affiliate Branches at its April meeting. A fifth Affiliate Branch was admitted at the June meeting and 72 Student affiliates were accepted for enrollment.

The five institutions in which Affiliate Branches are now established are: Lamar State College, Beaumont, Tex.; Texas College of Agriculture and Industry, Kingsville; University of Houston, Houston Tex.; Tennessee Polytechnic Institute, Cookeville; and Gannon College, Erie, Pa.

The purpose of the Committee on Student Branches in recommending Student affiliates and Affiliate Branches to the Board of Directors was to provide a channel for association with the Institute for these electrical engineering students, eligible upon graduation to become Affiliates but not Associate Members. The great demand for electrical engineering graduates in industry has stimulated establishment and development of new "community colleges," especially in growing industrial areas. Some of these are believed to be vigorous, purposeful, and well-supported institutions whose efforts are effectively directed towards accreditation.

Under the Bylaws and the operating policies of the Committee on Student Branches, the Student affiliate must meet all of the requirements of the Student member, except those applying to the accreditation of his school by Engineers' Council for Professional Development (ECPD). Only candidates for the bachelor's degree in electrical engineering in 4-year or equivalent curricula in colleges within continental United States and Canada, but not accredited by ECPD, are eligible.

Student affiliates receive all of the publications and other privileges accorded Student members except that, upon graduation, they become eligible for admission to the Institute as Affiliates. As students, they receive a distinctive membership badge with a green background for the standard student emblem. After graduation, they pay no entrance fee as Affiliates and may transfer to the grade of Associate Member when the requirements of that grade are met.

An Affiliate Branch is entitled to the same financial support as the Student Branch and enjoys the same privileges with respect to travel, prizes, competition, and other activities. A counselor is nominated and appointed by the usual methods. He may not, however, serve as chairman of the District Committee on Student Activities.

The establishment of an Affiliate Branch calls for approval by the chairman of the District Committee on Student Activities, the District Vice-President, the Institute Committee on Student Branches, and the Board of Directors. This approval will, for the present, be limited to 4-year schools or those having an equivalent curricula, awarding the bachelor's degree in electrical engineering within continental United States and Canada. Otherwise, the establishment of an Affiliate Branch follows the requirements of the current By-laws and policies of the Institute.

If the electrical engineering curriculum with which an Affiliate Branch is identified becomes accredited, the Affiliate Branch may, by action of the Board of Directors, become a Branch of the Institute. If an accredited electrical engineering curriculum loses its ECPD accreditation, the associated Branch may continue for 2 years, including the year in which notice of withdrawal of accreditation is issued; thus providing continuity of privileges for juniors and seniors with respect to Associate Membership in the Institute.

Petroleum Industry Electrical Conference Is Scheduled for This Month in Houston, Tex.

THE ANNUAL Electrical Conference of the Petroleum Industry will be held this year at the Shamrock Hotel in Houston, Tex., September 12–14. The Houston Section, AIEE, has joined the Petroleum Industry Committee as sponsors.

The aim of the conference is to advance the profession of electrical engineering and to provide an interchange of electrical technology through an industry-wide coverage of its applications in oil and gas production, refining, transportation, and allied petrochemical fields.

Houston has a metropolitan population of more than a million and is the largest city in the south. It is in the heart of the oil-producing, refining, and organic chemical area of Texas. The Houston territory, comprised of 19 counties, accounts for 14 per cent of the state's crude oil production, 40 per cent of the Texas' and more than 11 per cent of the national refinery operations. A huge network of pipe lines moves crude oil from the fields to the refineries and in and out of the area. Natural gas is transported within and outside of the area through major pipe lines. Movements of crude oil and refined products by tankers contribute greatly to making Houston the nation's second largest deep seaport in total tonnage moved.

Technical Sessions

Outstanding engineers in their fields will present 24 papers at the technical sessions covering a broad variety of electrical subjects in the production, transporation, and refining phases of the industry. The most recent developments in maintenance practices and in the use of electric equipment will be discussed. All interested persons are invited to attend whether they are electrical, petroleum, mechanical, chemical, or communication engineers, or operating or maintenance personnel. The completely air-conditioned facilities of the Shamrock Hotel will be used for all technical sessions.

Advance Copies of Papers

Advance copies of conference papers may be obtained by writing to R. S. Gardner, Assistant Secretary, Technical Activities, Committee on Technical Operations, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Inspection Trips

Interesting inspection trips which will not conflict with the technical program have been arranged. Transportation trips include Transcontinental Gas Pipe Line Corporation's microwave communication and control headquarters, and The Texas Pipe Line Company's East Houston Station. The East Houston Station is modern in every respect and will be of interest to engineers engaged in this phase of the business.

Production field trips include: Schlumberger's multi-million dollar, modern oil well surveying equipment assembly plant; and Hughes Tool Company's equipment manufacturing facilities. At Hughes Tool Company, drilling in various formations will be demonstrated on the world's only air-conditioned drilling rig.

Refining field trips are scheduled for the Sinclair refinery and Humble Oil and Refining Company's Baytown refinery. The complete electric systems, instrumentation, and process controls will be seen at both refineries.

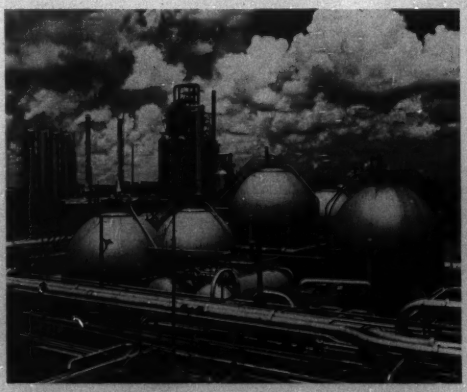
Ladies' Activities

A get-acquainted coffee for ladies is scheduled for Monday morning in the Ladies' Hospitality Room which will be open throughout the conference. There will be a luncheon and style show Tuesday, as well as sight-seeing arranged for out-of-town guests. Visitors may see points of interest in and around Houston, with particular emphasis on the famed River Oaks residential area, Foley's Neiman-Marcus, and Sakowitz stores. There is no registration charge for ladies.

Social Activities

A luncheon for the men will be held Monday at noon in the Emerald Room. This is being planned as a get-acquainted affair and as an entertaining interlude between the morning and afternoon technical sessions. It will be a period of fellowship for the conferees. The price is $3.50 per plate.

On Tuesday evening, a fellowship and social hour is scheduled on the Shamrock pool terrace for all registrants and ladies. An informal banquet for both men and women will follow in the Emerald Room. The address for this occasion will be given by Dr. Carey Croneis, provost of The Rice Institute, Houston. The charge for the banquet is $7.50 per person.



OPEN FOR INSPECTION during the Electrical Conference of the Petroleum Industry, September 12–14, will be the Humble Oil and Refining Company's Baytown Refinery at Baytown, Tex. A part of the refinery is shown.

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until *October 28*. Duplicate double-spaced typewritten copies of each discussion should be sent to Edward C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y., on or before *October 28*.

55-247 Analysis of Single-Phase to 3-Phase Static-Phase Converters. *J. C. Hogan*

55-548 Correlation Between Root-Locus and Transient Response of Sampled-Data Control Systems. *E. I. Jury*

55-505 Design of High-Precision Synchros and Resolvers. *R. A. Heartz, R. M. Saunders*

Preprints may be purchased at 30¢ each to members, 60¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th Street, New York 38, N. Y.

Recreation

Many recreational and historical facilities also may be enjoyed while visiting Houston. Among them are interesting parks, golfing, fresh and salt water fishing, the San Jacinto Monument and Museum which mark the site of the battle where Texas won her independence from Mexico, the Museum of Natural History, and the $1,000,000 Museum of Fine Arts.

Reservations

Requests for hotel reservations should be mailed directly to the Shamrock Hotel in Houston. Rates are: single rooms, $6.00–$18.00 per day; double rooms with twin or double beds, $8.00–$18.00 per day; 1-room suites, $12.00–$18.00 per day; parlor and 1-bedroom suites, $25.00–$30.00 per day; 2-bedroom suites with parlor, $45.00–$60.00 per day.

Registration

The advance registration fee for the conference is $3.50. For registration at the door at the time of the conference, the charge is $4.00. Checks should be made payable to Clifton D. Campbell, Treasurer, Electrical Conference of the Petroleum Industry.

Anyone who has not received registration forms should write to J. C. Gardner, Westinghouse Electric Corporation, 507 Dallas Avenue, Houston 2, Tex. The tentative technical program follows:

Monday, September 12

8:00 a.m. Registration—Shamrock Hotel

10:00 a.m. General Session

10:30 a.m. Technical Session

W. H. Dickinson, presiding

Current Practices in Classifying Areas for Electrical Installations. *L. M. Goldsmith*, Atlantic Refining Company

CP55-641 Power System for New Refinery with Major Electric Drives. *N. A. Austin*, Standard Oil Company of California

12:30 p.m. Luncheon

2:00 p.m. Technical Session

W. H. Dickinson, presiding

CP55-638 Modern Protective Relaying for Refinery Electric Systems. *W. C. Woods*, Westinghouse Electric Corporation

System Neutral Grounding for the Petroleum Industry. *D. S. Brereton, N. N. Hickok*, General Electric Company

CP55-640 34.5-Kv Station-Type Cubicle Switchgear in a Petroleum Refinery. *W. E. Highfill*, Esso Research and Engineering Company

CP55-642 Motor Starting Problems in a Petroleum Refinery. *L. B. Eddy*, Universal Oil Products Company

Tuesday, September 13

9:30 a.m. Technical Session

W. H. Dickinson, presiding

High-Voltage Motor Controllers for the Petroleum Industry. *T. J. Render*, General Electric Company

CP55-631 Lighting in a Petroleum Refinery. *B. E. Gilman*, Standard Oil Company of Indiana

Insulated Cables and the Petroleum Industry. *E. E. Mellowne*, Okonite Company

Installation and Maintenance of 15.8-Kv Gas-Filled Cable Installation. *B. E. Crawford, J. A. Darden*, Esso Standard Oil Company

9:30 Technical Session

J. R. Ashley, presiding

Electric Power in Modern Gasoline Plant Construction. *E. A. Naser*, Hudson Engineering Company

CP55-635 An Attempt to Reduce Glare During Night Operations on a Drilling Rig. *J. R. Street*, Texas Employer's Insurance Association.

CP55-634 Capacitors for Beam Pumping. *R. K. Owen*, Southwestern Public Service Company

2:00 p.m. Technical Session

M. H. Halderson, presiding

A Solution to the Problems of Oil Well Drilling in Urban Areas. *Earl Knox*, Packo Consulting Engineers; *E.E. Hogwood, Jr.*, Westinghouse Electric Corporation

***New Applications of Electric Drives to Drilling Rigs.** *G. W. Webb*, General Electric Company

*Paper not available for preprinting by AIEE, but author will provide copies at the meeting.

***Electrical Wiring of Drilling Barges and Offshore Structures.** *H. S. McIntosh*, McIntosh Electric Supply Company, Inc.

2:00 p.m. Technical Session

R. S. Cannon, presiding

CP55-629 Maintenance of Gas Turbine Equipment in Natural Gas Pumping Stations. *J. C. Arnold*, El Paso Natural Gas Company

CP55-632 Special Applications of Standard Switchgear for Pipe Line Substations. *V. G. Murdock*, Allis-Chalmers Manufacturing Company

CP55-633 New Horizons in Gauging and Sampling. *F. E. Neef, Jr.*, Gilbert and Barker Manufacturing Company

CP55-637 Automatic Operation of Pipe Line Pump Stations. *C. S. Williams*, Texas Pipe Line Company

6:30 p.m. Fellowship and Social Hour

7:30 p.m. Banquet

Wednesday, September 14

9:30 a.m. Technical Session

A., R. Heiderbrecht, presiding

***CP55-643 Present Status of Remotely Supervised Oil Trunk Line Pumping Stations.** *E. B. Turner*, General Electric Company

CP55-636 Modernized and Simplified Methods for Controlling Pumping Stations Automatically. *R. J. Thompson, T. H. Puckett*, Carnahan and Thompson, Engineers

CP55-630 Time Code Control and Data-Handling Systems. *P. K. Eckhardt*, Union Switch and Signal Company

CP55-639 Instruments and Their Safety Functions for Today's Pipe Lines. *P. J. Provost*, The Mercoid Corporation

Atomic Energy Study Program to Be Presented by New York Section

The educational committee of the Power and Industrial Division of AIEE's New York Section is presenting a full year's educational program covering "The Principles and Engineering Application of Atomic Energy." This follows the extremely successful 12-session series given last fall by the same group. At that time more than 70 per cent of the 152 engineers in attendance expressed a desire for further and more detailed study.

The new program gets under way on October 5 with a discussion of the Atomic Energy Act of 1954 by C. Robbins, executive manager of the Atomic Industrial Forum. A brief review of theory will be given by Professor R. Wayne Houston of Columbia University. Walter F. Friend, atomic consultant for Ebasco Services, Inc., will discuss raw materials. Specific problems encountered in reactor design will be discussed by R. L. Mela, senior engineer of Nuclear Development Associates; Donald White, of the Atomic Knolls Laboratory of General Electric Company; J. R. Menke, president of Nuclear Development Associates; and J. W. Landis, sales manager of the Atomic Energy Division of Babcock and Wilcox.

Reactor types and applications will be discussed by R. M. Gould, manager of nuclear projects, Foster-Wheeler Company; D. M. Schoenfeld, manager of the Nuclear Power Division, Combustion Engineering Corporation; Clark Williams, Brookhaven

National Laboratory; William M. Thompson, chief engineer, Walter Kidde, Nuclear Laboratories; Samuel Untermeyer, II, atomic power study group, General Electric Company.

The fall session will be followed by an equally interesting spring session, consisting of 12 additional lectures. Mr. L. E. Gray is chairman of the Section's educational committee.

Technical Committee Chairmen Hold Meeting June 30, 1955

Chairman of the Technical Operations Committee, J. D. Tebo, opened the meeting of the technical committee chairmen Thursday evening, June 30th. During the discussion, L. J. Berberich, chairman, Committee on Basic Sciences, stated that there is difficulty getting papers from authors and suggested that a simplified "Author's Guide" might help. Dr. Ernst Weber agreed and then said that more details in the grading of technical and conference papers would assist committees in their decisions.

Mr. A. G. Oehler said that committee chairmen should do something about getting good papers. Members should be solicited first, but there are cases when nonmembers have material for papers that is unavailable to members.

This brought up for discussion the appointment of nonmembers to Subcommittees. Dr. Tebo said subcommittee chairmen should be members. Nonmembers may be on subcommittees but the Division's chairman must give his approval.

The next subject opened for discussion by Dr. Tebo concerned how much initiative technical committees should take in standards work. Chairman of the Standards Committee, A. C. Muir, said the rules are in the "AIEE Standards Manual," which he offered to send to any technical committee chairman. He reported that new data for the procedure of informing technical committees of the status of work in hand was nearly ready for distribution.

Dr. Tebo then told about the work of the Technical Operations' Subcommittee which is considering how the Institute can be brought closer to members. Mr. R. S. Gardner, Assistant Secretary, Technical Committee Activities, said it is difficult to send notices of technical conferences to members as there is no way to know what the members' chief interests are.

Mr. B. G. A. Skrotzki, chairman of the Power Division Committee, told about the formation of The American Society of Mechanical Engineers' Committee of 1,000 and its work.

The next subject discussed was that of the younger membership being adequately represented on technical committees. J. H. Miller said that the younger men should get committee reports and W. R. Clark, vice-chairman, Technical Operations Committee, suggested that young men should be on committees for the sake of experience in that phase of the work.

Dr. Tebo then asked for suggestions to improve the conducting of meeting sessions. Mr. Skrotzki remarked about the possibility of improving the quality of slide projection and suggested instructions for operators. Dr. Lewis suggested a vice-chairman who would attend to the physical requirements in a session, as the chairman of a session is too busy with speakers and the program. Mr. Skrotzki made a motion to set up assistant chairmen for sessions which was carried.

L. F. Hickernell, chairman, AIEE Committee on Planning and Co-ordination, was asked to review the findings of the Opinion Research Corporation of Princeton, N. J., which recently had submitted a survey report on Institute activities. These results will be made available later.

Summer Meeting Conference Papers Now Available

Copies of the following conference papers given at the AIEE Summer General Meeting, June 27–July 1, 1955, and which were furnished by the authors are now available at AIEE Headquarters at the standard price of 40 cents each to members and 80 cents each to nonmembers.

55-567. Analysis of Low-Voltage Capacitors in Series with Distribution Transformers. G. G. Auer, R. G. Livingston, R. J. Hopkins, and N. M. Neagle, General Electric Company

55-568. Economic Studies Applied to Industrial Power Systems. H. B. Backenstoss, Jackson and Mooreland Engineers

55-570. Protective Relaying and System Planning. J. E. Barkle and J. L. Blackburn, Westinghouse Electric Corporation

55-571. Challenges and Opportunities for Young Engineers in the Utility Industry. J. W. Bennett, Western Massachusetts Electric Company

55-572. Guiding Principles in the Thermal Evaluation of Insulating Materials. L. J. Berberich and T. W. Dakin, Westinghouse Electric Corporation

55-573. Teaching Ethics to Engineering Students. H. W. Bibber, Union College

55-574. Experimental Transistor Calculator. G. D. Bruce and J. O. Logue, International Business Machines Corporation

55-576. New Distribution Class Oil Circuit Breakers. E. J. Casey, T. R. Coggeshall, and R. H. Miller

55-577. What Ethics? C. T. Chave, Stone and Webster

55-578. Exciter Response. H. W. Cory, Allis-Chalmers Manufacturing Company

55-579. A Hydro Utility's Approach to Defining Excitation System Response. P. L. Dandeno and K. R. McClymont, Hydro-Electric Power Commission of Ontario

55-580. Recent New Features for the No. 5 Crossbar Switching System. J. W. Dehn and R. E. Hersey, Bell Telephone Laboratories, Inc.

55-581. Thermal Evaluation of Enameled Wire. J. F. Dexter, Dow Corning Corporation

55-585. The Philosophy of Codes of Ethics. L. L. Fuller, Harvard Law School

55-586. Factors Affecting Selection of Insulated Cable. R. C. Graham, Rome Cable Corporation

55-588. Prediction of Electronic Equipment Reliability Based on Design Factors. V. Harris and M. M. Tall, Vitro Corporation of America

55-589. System Neutral Grounding for Chemical Plant Power Systems. H. N. Hickok and D. S. Brereton, General Electric Company

55-592. Application of Low-Voltage Series Capacitors with Distribution Transformers. R. F. Lawrence and L. W. Manning, Westinghouse Electric Corporation

55-593. The Obligations of Engineering Management in a Large Decentralized Manufacturing Company. C. H. Linder, General Electric Company

55-596. Mechanical Shock Tests on Models of Dry-Type Transformers. G. A. Monito, Westinghouse Electric Corporation

55-595. Considerations of Microwave Installations. R. G. McLaughlin, Raytheon Manufacturing Company

55-597. Thermal Endurance Studies of High-Voltage Insulation Systems for Large Generators. G. L. Moses and J. C. Botts, Westinghouse Electric Corporation

55-598. National Bureau of Standards Preferred Circuits Program. J. H. Muncy, National Bureau of Standards

55-600. The Continuous Film Projector and Flying Spot Scanner for Television. R. E. Putnam, General Electric Company

55-603. Transit Modernization and Rapid Transit Development in Cleveland. M. W. Rew, Cleveland Transit System, and G. M. Woods, Westinghouse Electric Corporation

55-604. Application of Polyethylene-Insulated High-Voltage Power Cable in Chemical Plants. S. J. Rosch, Anaconda Wire and Cable Company

55-606. A Telephone Communication System for the Green Bay and Western Railroad. G. W. Searle and J. W. Deist, Wisconsin Telephone Company

55-607. Standard Functional Divisions for Electronic Equipment. R. S. Shultz and W. R. Waltz, Vitro Corporation of America

55-608. Excitation System Response—Definition and Significance in Power Systems. M. Temoshok, General Electric Company

55-610. A Study of Models for Use in Evaluating Dry-Type Transformer Insulating Systems. T. R. Walters and A. L. Scheideler, General Electric Company

55-611. Use of High-Strength Steel in Transmission Towers. H. M. Walton, U. S. Steel Corporation

55-613. A New Design of 13.8-Kv Metal-Clad Switchgear. T. G. A. Sillers and A. Ewy, Allis-Chalmers Manufacturing Company

55-614. A-C/D-C Conversion Equipment in the Electrochemical Industry. H. H. Zielinski, General Electric Company

Lamme Medal Nominations Must Be Submitted by December 1

Members of the Institute again are reminded that they have an opportunity to submit nominations for the 1955 Lamme Medal. All nominations must be received not later than December 1, 1955.

Details regarding qualifications for the award were published in the June 1955 issue of *Electrical Engineering*, page 539.

The Lockheed P2V-7

Aircraft Electrical Equipment Conference Will Be Held October 25–27 in Los Angeles

THIS YEAR the annual AIEE Aircraft Electrical Technical Conference will take place in Los Angles, Calif. The 3-day conference, sponsored by the AIEE Air Transportation Committee, will be held October 25-27 with headquarters at the Hollywood Roosevelt Hotel.

Plans for the technical program are nearing completion. Approximately 25 papers are being scheduled for presentation, with the broad scope of the program covering aircraft electrical power generation and controls, component design, and engineering department management. Papers are being selected for their bearing on problems being encountered in the design of present-day aircraft. Complete program details will be published in the October issue of *Electrical Engineering*.

Those attending the conference also will have an opportunity to attend the annual Aircraft Electrical Society display meeting, which will be held October 27 and 28 at the Pan Pacific Auditorium.

A number of interesting field trips are being planned for visitors and a complete and varied program of activities, including a trip to fabulous Disneyland, has been arranged for the ladies attending. A luncheon featuring a speaker well known in the aviation field will be held Wednesday, October 26.

Advance registration for the conference may be made by writing to H. B. Anderson, Westinghouse Electric Corporation, 600 St. Paul Avenue, Los Angeles 17, Calif. The registration fee will be $1.00 for nonmembers and there will be no fee for members. Conference proceedings, including all papers, will be available.

Committee

The conference committee chairman is F. L. Lyons. T. B. Holliday is in charge of the technical program, assisted by T. Owen. Other committee members are: O. Baumann, secretary; E. A. Freitas, finance; J. L. Elliott, hotel arrangements; C. R. Moore, program presentation arrangements; H. B. Anderson, registration; D. H. Stephens, field trips; J. J. Pierro, publication; H. F. Rempt, banquet; Mrs. H. F. Rempt, ladies program; C. W. Chandler, publicity, assisted by J. Camlin and C. W. Bozarth. AIEE Headquarters representative for the conference is R. S. Gardner.

The title picture shows the Lockheed P2V-7 with the new tail that contains magnetic instruments to detect presence of submarines even though they may be completely submerged. It is the latest version of the famed Neptune series of antisubmarine planes. It is powered by two jet engines housed in underwing pods to augment its two turbocompound piston engines.

1955 National Electronics Conference Scheduled for October 3–5 in Chicago, Ill.

NINETY-SIX papers covering a broad field of electronic research and development and industrial application make up the technical program scheduled for the eleventh annual National Electronics Conference (NEC). Supplementing this program will be more than 180 booth exhibits of manufacturers in the electronics field. This year's conference will be held at the Hotel Sherman in Chicago, Ill. (AIEE's Fall General Meeting will be held October 3–7 in Chicago at the Morrison Hotel.)

Sponsors of the conference are: AIEE, Institute of Radio Engineers, the Radio-Electronics-Television Manufacturers Association, the Society of Motion Picture and Television Engineers, the Illinois Institute of Technology, Northwestern University, University of Illinois, Michigan State University, Purdue University, University of Michigan, and the University of Wisconsin. President of the Conference is O. I. Thompson of De Vry Technical Institute, Chicago.

Social Activities

Three luncheons will each feature a prominent speaker. On Monday the luncheon address will be given by A. V. Astin, director, National Bureau of Standards, Washington, D. C.; on Tuesday by J. M. Robson, Atomic Energy of Canada, Ltd., Chalk River, Ont., Canada; and on Wednesday by Ernst Weber, chairman, department of electrical engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

The conference has been invited to participate in the smoker held by AIEE on Monday evening and on Tuesday the NEC party will take place in the Bal Tabarin with dinner, entertainment, and dancing. And, there are separate entertaining activities planned for the ladies.

Registration

Advance registration may be made by writing to the National Electronics Conference, Inc., John S. Powers, Executive Secretary, 84 East Randolph Street, Chicago 1, Ill.

The tentative technical program for the National Electronics Conference follows:

Monday, October 3

Morning Session

Audio and Acoustics
Transistor Amplifiers
Antennas
Magnetic Amplifiers

Afternoon Session

Symposium on Solid-State Electronics
Instruments and Measurements
Electron-Tube Amplifiers and Oscillators
Computers and Computer Elements

Tuesday, October 4

Morning Session

Communication Theory
Microwave Tubes and Components
Transistor Applications
Medical Electronics and Ultrasonics

Afternoon Session

Symposium on Radio Astronomy
Modern Methods in Circuit Analysis
Solid State Devices
Electronic Systems

Wednesday, October 5

Morning Session

Circuit Theory
Radar and Navigation
Ultrasonic Devices and Techniques
Ferroelectric and Ferromagnetic Circuit

Afternoon Session

Electronic Circuit Design
Waveguides and Transmision Lines
Servomechanisms and Control
Reliability Consideration in Electronic Equipmen

Industrial Electronics Conference to Be Held September 28-29, 1955

THE 1955 Industrial Electronics Conference will be held at the Rackham Memorial Auditorium in Detroit, Mich., September 28–29. The meeting is sponsored by the Michigan Section of the AIEE, the Professional Group on Industrial Electronics, Detroit Section, Institute of Radio Engineers (IRE). Sixteen papers have been scheduled for the four technical sessions at which automation, industrial measurement problems, and new control system applications, will be discussed.

Conference registration will be $2.00 to members of the IRE and AIEE and $3.00 to all others The conference hotel will be the Park-Shelton and hotel reservations should be made prior to September 10. Information concerning advance conference registration and hotel reservations may be obtained from Guido Ferrara, 8106 West Nine Mile Road, Oak Park 37, Mich.

The tentative program for the 2-day conference is as follows.

Tentative Technical Program Industrial Electronics Conference

Wednesday, September 28

8:30 a.m. Registration at the Rackham Memorial Auditorium

9:30 a.m. Session I: Electro-Optical Devices and Applications

Miniature Strobelight System for a 60,000-rpm Bearing Tester. *John Patraiko*, Ford Motor Company

An Instrument to Count and Size Particles in a Gas. *E. S. Gordon*, Armour Research Foundation

Industrial Applications of a High-Speed Spectrum Analyzer. *N. L. Duncan*, Raytheon Manufacturing Company

How Can Industry Use Television? *H. F. Schneider*, Radio Corporation of America

12:30 p.m. Luncheon at the Engineering Society of Detroit

Speaker: *John R. Robertson*, Manager, Administrative Services, Engineering Division, Chrysler Corporation. ($2.75 per person)

2:30 p.m. Session II: Measuring and Recording Instruments and Applications

Capacitive Measurements of High Sensitivity and Their Applications to Industrial Testing and Control. *George Reness*, Robertshaw Fulton Control Company

Some Applications of a Capacity Micrometer to High-Speed, High-Temperature Measurements. *Ralph Condit*, Ford Motor Company

Principles of Radioactive Gauging Applied to Measurements and Control in the Process Industry. *D. C. Brunton*, Isotope Products, Ltd.

A Frequency-Modulated Magnetic Recorder. *Walter Richter*, Cutler-Hammer, Inc.

Thursday, September 29

9:30 p.m. Session III: Process Control and Systems Analysis

Automatic and Semiautomatic Steel Flow Control Systems. *R. D. Morrow*, Morrow Products, Inc.

Problems in the Control of Nuclear Reactor Steam-Electric Power Plants. *William Kerr*, University of Michigan

Ultrasonic Impact Grinder—Industrial Tool. *K. W. Henderson*, Raytheon Manufacturing Company

Automatic Controlled Electrolytic Grinding. *Eugene Mittelmann*

12:30 p.m. Luncheon at the Engineering Society of Detroit

($2.75 per person)

2:30 p.m. Session IV: Automation and Machine Tool Control

(To be Announced). *Cledo Brunetti*, General Mills, Inc.

Automation Re-examined. *J. J. Graham*, Radio Corporation of America

A Numerically Controlled Cam Milling Machine. *E. C. Johnson*, Bendix Aviation Corporation

2-Motion Duplicator for Machine Tool Control. *A. J. Carr, Jr.*, Raytheon Manufacturing Company

Heating and Cooling Space Equipment Conference Scheduled

The Conference on Application of Motors to Space Heating and Cooling Equipment will be held in St. Louis, Mo., on October 19 and 20 at the Chase Hotel. The program will include four technical sessions during which 16 papers will be discussed covering various phases of the problems and solutions of the application of motors to space heating and cooling equipment. Registration will be from 9:00 to 9:30 a.m. on Wednesday.

This conference is being sponsored jointly by the St. Louis Section of AIEE and the Single Phase and Fractional Horsepower Subcommittee of the Committee on Rotating Machinery. There will be conference luncheons on Wednesday and Thursday and, in addition, a Wednesday night banquet meeting with the St. Louis Section.

General chairman for this conference is R. F. Munier, chief motor engineer, Emerson Electric Manufacturing Company. Other committee chairmen are: C. D. Fall, finance; J. L. Hamilton, program chairman; W. E. Korsan, arrangements; J. K. Howell, registration and reservations; and J. E. Roomy, publicity.

Papers Solicited for 1956 Western Computer Conference

The Western Computer Conference will be held in San Francisco, Calif., February 8–10, 1956. It is sponsored jointly by the AIEE, Institute of Radio Engineers, and the Association for Computing Machinery.

Papers on all phases of the computer field are now being solicited. In addition to the title, authors are asked to submit an abstract of approximately 200 words, suitable for reproduction in the program, and either the complete manuscript or sufficient additional information to permit evaluation by the Technical Program Committee. Early submission of papers is desired. Final deadline is November 15, 1955. This is the latest date that is operationally feasible and papers received thereafter cannot be considered.

Authors should indicate any plans for publication and should state what facilities, such as slide or movie projectors, power sources, etc., are required. For uniformity of handling, it is requested that all papers be sent to: Byron J. Bennett, Chairman, Technical Program Committee, Western Computer Conference, Stanford Research Institute, Menlo Park, Calif.

Eastern Joint Computer Conference to Be Held November 7–9, 1955

"Computers in Business and Industrial Systems" is the theme of the 1955 Eastern Joint Computer Conference and Exhibition to be held under the sponsorship of AIEE, the Institute of Radio Engineers, and the Association for Computing Machinery at the Hotel Statler, Boston, Mass., November 7–9.

Technical papers will appeal to businessmen interested in using electronic computers and clerical machines for payrolls, accounts receivable, inventory problems; to plant engineers interested in using electronic computers to control oil refineries, chemical plants, machine tools, materials-handling equipment; and to engineers and makers of computing and data-processing systems and components.

Exhibits will include electronic data-processing systems, process control systems, storage systems, input-output equipment, conversion devices, and sensing devices.

Philadelphia Section Makes New Organizational Plans

One of the most active Sections in the Institute, the Philadelphia Section, has recently undergone organizational changes. It is thought that these changes may be of interest to the other Sections of AIEE. The Section's "new look" was first begun several years ago when the Board of Managers of the Section thought that their discussion group set-up was, for various reasons, in need of a complete overhaul and reorganization.

Originally, the concept was that only the discussion groups needed reorganization. It soon became apparent, however, that such reorganization would necessarily entail slight modification of the Section organization if it were to be effective both then and in the future. It appeared advantageous to organize and operate the discussion type of activity under technical divisions of the section, and special committees were appointed by the Section chairmen to study the problem in detail. After several years of effort, the committee presented its report which was accepted by the membership and adopted. The committee worked toward the following objectives:

1. To provide a co-ordinated technical program for the Section

PHILADELPHIA SECTION'S officers, committee chairmen, and members of the Section's Board of Managers are shown above. The Section has recently undergone organizational changes to provide a co-ordinated technical program for Section members. It is thought that this reorganization may be of interest to other Sections (see pp. 831–33). Seated (left to right): W. S. Osborne; R. G. Lex; H. B. McCurdy; R. S. Hewett; G. B. Schleicher, secretary; A. E. Pringle II; T. E. Stieber, chairman; M. J. Dugan, vice-chairman; H. U. Davis; F. D. Brown; R. R. Wagstaff; E. B. Shew; M. R. Stoughton. Second row (left to right): B. F. Campbell; W. R. West; C. R. Hansen; W. J. Johnson; W. O. Mascaro; E. F. Jones; J. C. Taylor; R. P. Hunt. Back row (left to right): H. F. Davis; A. H. Sellers; R. J. McTamney; M. D. Ewing; J. M. Bracken; W. E. Scholz; W. G. Amey; W. R. Clark; A. P. Hendricks.

2. To represent the interests of the younger engineers at the top levels of Section administration

3. To provide a better basis for co-ordinating the activities of the newly-formed technical divisions of the Philadelphia Section with the activities of the technical divisions and committees of the Institute

4. To provide the means of regularly advising Section officers and the Section board of managers of additional areas of technical interest which should be represented in Section activities

5. To improve the basis for expansion or contraction of all technical division activities whenever such is considered advisable by the board of managers without requiring revision of the Section By-laws

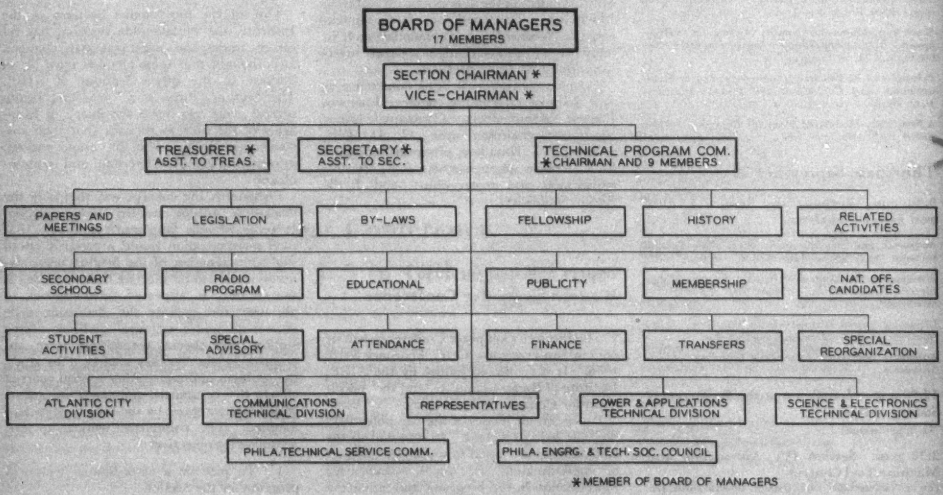
As seen from the organization charts (below) the primary responsibility for the operation of the Section rests with the Section chairman, subject to the approval of the board of managers. The Section vice-chairman, secretary, and treasurer serve as staff assistants to the Section chairman. The chairmen of the Atlantic City Division, of special or standing committees, and of the technical divisions, all report directly to the Section chairman.

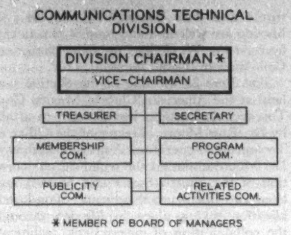
The interest of the technical divisions will be represented at top levels of Section administration by the chairmen of the technical divisions who, when elected to membership of their respective technical divisions, automatically become members of the board of managers during their tenure of office. The privilege of top level representation now afforded to divisions which may number only 20 to 50 persons is thus extended to the new technical division which may have several hundred members.

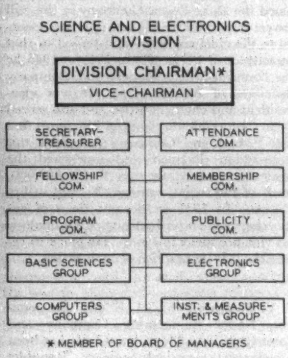
The technical program committee, under the guidance of the Section vice-chairman, provides a basis for achieving the previously cited objectives concerned with the co-ordination of the Section technical program. Operating in an advisory capacity, the technical program committee will co-ordinate the technical program subject to approval of the board of managers.

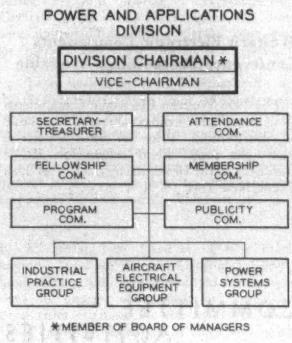
While administration of the Philadelphia Section under the new plan has only been in effect a few months, its value has already been apparent. The Section looks forward

1955-56 ORGANIZATION – PHILADELPHIA SECTION AIEE









to a successful year and to more Section interest in Institute affairs under the new plan.

Another interesting project of the Philadelphia Section has been a weekly tape-recorded broadcast over FM radio station WFLM. This is a series titled, "Meet the Engineer." The purpose of this series is to foster public interest in AIEE and the engineering profession in general. Speakers are outstanding engineers and have included men of world-wide reputation. The program has received wide attention and numerous requests have been made for many of the broadcast recordings.

AIEE Vice-Presidents Meet With Student Branch Counselors

VARIOUS WAYS of stimulating interest in the Student Branch activities were considered at the meeting of Vice-Presidents and Student Branch counselors, at the Summer Meeting, with Walter B. Morton, Chairman of the Student Branches Committee, presiding. In opening the meeting, the chairman referred to accomplishments during the past 2 years and five ways in which the Sections could be of assistance to the Branches. It was pointed out that of prime importance is the appointment of a Student Activities Committee through which the Section can have direct contact with the branch. The student branch counselor may be appointed to the Executive Committee of the Section, and students can be placed on the Section mailing list. Also, student competitions should be encouraged. Father-and-son subsidized dinners have been successful and joint Section-Branch meetings was another suggestion.

In regard to the Student Branches, also, reference was made to a resolution proposed to the Board of Directors that it was highly desirable for Vice-Presidents to make at least one visit to each Branch and to each Section during the year. It was considered more important that the Vice-Presidents sit down with the counselors and discuss affairs, rather than make a talk.

Prize student paper competitions in which the students do very well and it is often difficult to judge winners were considered valuable by Mr. Morton. J. L. Callahan also urged that the prize paper competitions and industry-financed visits for winners be encouraged. Professor R. T. Weil, Jr. complimented the Radio Corporation of America (RCA) on the very fine trips arranged to the RCA Laboratories for the winners in Districts 1, 2, and 3. Hope was expressed that industries in other districts could be persuaded to arrange such trips to include the first, second, and third prize winners and the counselors.

In relation to the formation of Student Branches and Affiliate Branches, Vice-President G. C. Tenney referred to the Naval Postgraduate School at Monterey, Calif. He said that the San Francisco Section members thought the Naval Postgraduate School had the proper qualifications for the establishment of an Affiliate Student Branch and that this would be recommended.

The attendance of Student Branch chairmen at meetings of the District committees on student activities and the desirability of holding an extra meeting in each of the Districts in the fall received lively discussion. This would depend upon prevailing conditions within the different Districts.

In connection with a travel allowance for counselors to attend Student Branch conventions, several counselors reported on the different steps taken to provide transportation. Regarding the sum necessary, Director E. W. Seeger explained that certain sums depending on mileage, were under consideration.

It was stated that in District 5, with an average travel distance of 300 miles and 70 people in attendance, the cost would be approximately $2,700 for a meeting. It was not believed there would be much of a case for an additional travel allowance and the request would have to have a very strong recommendation.

Additional prizes for students were provided in several Districts. In District 1, any available district funds were used to help the students. Sections also have donated funds and the Los Angeles and San Francisco Sections provide additional student funds. Several Districts expressed the view that additional certificates for outstanding student branch members were desirable. In District 2, it was suggested the prizes at the schools should be withheld and presented by the Vice-President at the District prize paper competition.

With regard to the use of branch meeting reports, Chairman Morton said that every school should send a report of every meeting to headquarters, and that funds be proportioned accordingly. The requirement of reports is in the Student Branch Manual. Professor E. T. B. Gross thought that a copy of the report should be given to the counselor and the procedure should be incorporated in the instructions.

With regard to publicity material, booklets, flyers, and so forth, the view was expressed that these should start with illustrations of electronic equipment and radio antennas to emphasize that the Institute is not a power organization. Chairman Morton stated that one of the student member pamphlets was fine but the picture on the cover was unrealistic. Indications were received that posters are put to good use and are considered valuable. The view was expressed, too, that all literature did not measure up but *Electrical Engineering* was considered easy to read.

In connection with methods of encouraging students to enter the engineering field, attention was drawn to the Eta Kappa Nu film, "Engineering, A Career", (see *Electrical Engineering*, August 1955, page 744.) Inquiries concerning the film should be sent to Eta Kappa Nu Association Headquarters, P. O. Box 447, Dillsburg, Pa. In conclusion, Past-President Montieth indicated the importance of student activities and said he was glad the vice-presidents were working on

the matter of getting the sections and branches to co-operate. The students like recognition and finding ways to give them recognition is an excellent activity. Anyone who has ideas should go ahead and try them and inform headquarters how they worked. President-Elect M. D. Hooven stated that the tradition of democracy and local autonomy must be maintained and that he and Past-President Monteith were in complete agreement on the ability to do things at home locally.

Mexico Section Invites Visiting Members to Meetings

Technical dinner meetings of AIEE's Mexico Section are held on the third Thursday of each month. Members of the Institute and their friends who plan to visit Mexico are welcome and may obtain tickets from Arthur W. Gelbke, publicity chairman, Calle Bolivar 21-609, Mexico 1, D. F.

The June 23 meeting of the Section was held at the American Club in Mexico City. This technical session was devoted to a talk by Dr. Ross Moore, director of the Office of Technical Co-operation, American Embassy. Dr. Moore discussed the technical co-operation of the United States and Mexico and cited the phenomenal advance of industrialization taking place in Mexico through the collaboration of government, technical, and financial interests of the two countries.

MEXICO SECTION's June 23 meeting was centered around guest speaker Dr. Ross E. Moore (left), director, Office of Technical Co-operation, American Embassy; To his right is Hector Martinez D'Meza, Section Chairman.

Western Electronic Components Conference Proceedings Available

The 1955 Western Electronic Components Conference proceedings are now available for distribution. Price for these reports is $4.50 per copy. Send orders to: R. S. Gardner, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Note. Because of the changeover in committee personnel, no items on committee activities are included in this issue.

AIEE PERSONALITIES.....

N. B. Higgins (AM'19, F'48), president of Safe Harbor Water Power Corporation, Baltimore, Md., has retired after 41 years of service in the electrical industry. A graduate of Pennsylvania State College with a bachelor of science degree in civil engineering, Mr. Higgins' early experience was as a structural draftsman with the Cambria Steel Company and the Penn Bridge Company. In 1910, he moved to Baltimore, Md., where he became associated with the Baltimore Bridge Company as a structural estimator. He later spent several years with the Western Maryland Railway Company as designer-erector of bridges, buildings, piers, and terminals. In 1914, he joined the Pennsylvania Water and Power Company as chief draftsman in the Baltimore office. Successively, he was assistant chief engineer, chief engineer, and advisory engineer in that office. When the Safe Harbor Water Power Corporation was formed, Mr. Higgins became its assistant chief engineer and, later, chief engineer. In 1942, he was elected president and a director of the Safe Harbor Corporation, the position he held until retirement. During his association with both Pennsylvania Water and Power Company and Safe Harbor Water Power Corporation, Mr. Higgins bore a large measure of the responsibility for the successful completion of the Holtwood hydroelectric and steam-electric projects and the Safe Harbor hydroelectric project on the Susquehanna River. He has written articles for the technical press dealing with hydroelectric development and associated problems. Mr. Higgins is a fellow of The American Society of Mechanical Engineers, a member of the American Society of Civil Engineers, American Welding Society, American Concrete Institute, and the Engineers Club of Baltimore. He is a Registered Professional Engineer in New York, Pennsylvania, and Maryland.

C. L. Emerson (M '20, F '33), for the past 10 years vice-president of Georgia Institute of Technology, retired July 1. He was graduated from Georgia Institute of Technology with a degree in mechanical engineering in 1908 and a degree in electrical engineering in 1909. After 5 years as application engineer with Westinghouse Electric Corporation, he joined the Duke Power Company in the mill power department. He later became assistant to the chief engineer, and served in that capacity until 1919. From 1919 to 1945 he was connected with Robert and Company Associates of Atlanta, Ga. He was vice-president and chief engineer, and also served 3 years as president. During his connection with Robert and Company Associates this organization designed and supervised the construction of slightly over $1,000,000,000. worth of industrial, commercial, and utility projects. In 1945 he became dean of engineering at Georgia Institute of Technology and vice-president in 1948. He plans to resume the private practice of engineering.

W. V. Boughton (M '41, F '48), vice-president, Nader Engineering Company and Motordyne, Inc., Monrovia, Calif., has been named chief electrical engineer, Republic Aviation Corporation. This is one change resulting from a revision of Republic's engineering organization to facilitate engineering of increasingly complex subsystems of present and future aircraft. Mr. Boughton joined Republic in December 1954. He started in aircraft electrical work at the Douglas Aircraft Corporation, Santa Monica, Calif., in 1925. He became chief of the equipment section in 1930 and remained with Douglas until 1948, when he became vice-president and general manager of the Phaostron Company, South Pasadena, Calif. In 1953 he became vice-president of the Nader Engineering Company, Monrovia, Calif., and sales vice-president of Motordyne, Inc., an associate company. Mr. Boughton has served on the following committees of the Institute: Air Transportation (1942–44, 1949–55, chairman 1949–51), Technical Program (1949–50), Standards (1949–50), General Applications Division (1949–51).

W. S. Edsall (M'19), president of The Chase-Shawmut Company, Newburyport, Mass., has been awarded the honorary degree of doctor of engineering by the University of Montana at Montana State College (Bozeman). After graduation from Montana State College, Mr. Edsall completed an engineering student course at Westinghouse Electric Corporation, East Pittsburgh, Pa., and later was a switchgear specialist in the New York, N. Y., office. He spent 2 years as a lieutenant in the submarine service in World War I. Following that, he was with Sperry Gyroscope Company in Brooklyn, N. Y., and later with Conduit Electric Manufacturing Company of Boston, Mass. He was general sales manager of American Brown-Boveri Electric Corporation and then was

assistant manager of the electrical department of Allis-Chalmers Manufacturing Company. In 1943 he was appointed manager of the Switchgear and Control Divisions of Allis-Chalmers. In 1945 he joined The Chase-Shawmut Company as vice-president and was elected president shortly thereafter. At present he is a member of the board of governors of the National Electrical Manufacturers Association. He has also been a member of AIEE's Protective Devices Committee (1923–36, 1942–44).

D. C. Ports (AM '38, M '47), chief engineer, Jansky and Bailey, Inc., Washington, D. C., has been elected vice-president of the company. Mr. Ports received his bachelor of science degree in electrical engineering at the George Washington University and his master of science degree from Ohio State University. As an engineer for Jansky and Bailey, which he joined in 1936, Mr. Ports was engaged in antenna design and installation projects and in wave propagation studies. He also did laboratory work in the development of high-frequency measuring techniques and equipment. With the advent of World War II, he took part in a number of research projects sponsored by the Office of Scientific Research and Development involving antenna characteristics, propagation phenomena, and communication systems. He was in charge of programs to develop techniques and measure characteristics of high-frequency antennas. He also supervised research which experimentally isolated some of the factors affecting propagation in the high-frequency and very-high-frequency regions. During this period the company established a laboratory to measure communication systems in use by the military, particularly under conditions of heavy interference, and Mr. Ports assumed responsibility for this work. Mr. Ports is active in professional affairs and is a senior member of The Institute of Radio Engineers (IRE) and an associate member of the Acoustical Society of America. He serves on a number of technical and professional committees including the Joint IRE-AIEE Committee on High Frequency Measurements.

F. K. Harris (AM'42, M'47), associate physicist, National Bureau of Standards, Washington, D.C., has received the Silver Medal for Meritorious Service from the U. S. Department of Commerce. He received the award in recognition of accomplishments in electrical instrumentation and measurements and for authorship of a book on electrical measurements. Dr. Harris joined the Bureau's staff in 1925 as a physicist in the electrical instruments section. At the present time, he is engaged in making evaluations of the theoretical and practical limitations of the essential components of low-level voltage-sensitive detectors and measuring devices, together with their co-ordination in detecting and measuring systems. From 1923–1925, Dr. Harris was a research fellow for the Munsell Color Company in the Colorimetry Section of the National Bureau of Standards, and prior to this, an instructor in physics at the University of Oklahoma, Norman. Born in 1902 in Indiana, Dr. Harris attended Southwestern State Teachers College, receiving his bachelor of arts degree from the University of Oklahoma in 1921. He received his doctorate in physics and electrical engineering in 1932 from Johns Hopkins University. He is the author or coauthor of a number of publications, is associate editor of *Review of Scientific Instruments*, a professorial lecturer in electrical engineering at George Washington University, and a coinventor of an electrical method for diamond die production. He is a member of the Washington Academy of Sciences, and also has served on the following AIEE committees: Basic Sciences (1947–52) and Instruments and Measurements (1951–55).

T. E. Stieber (AM'39, M'51), electric utility regional manager, Westinghouse Electric Corporation, Philadelphia, Pa., has been named Philadelphia district manager for the company. Mr. Stieber is a graduate of the Drexel Institute of Technology. He has been associated with Westinghouse in the Philadelphia Office since 1925, serving as switchgear specialist, manager of the general mill section, and most recently, electric utility regional manager. In 1939, he received the Westinghouse Order of Merit, highest award given by the company to employees for outstanding achievements.

L. K. Stringham (AM'34, F'49), chief engineer, Lincoln Electric Company, Cleveland, Ohio, has been appointed vice-president in charge of engineering. He has been chief engineer for the company since 1951. **George Landis** (M'35, F'40), who has been the engineering vice-president, is now vice-president in charge of research. Mr. Stringham joined the Lincoln engineering department in 1933 immediately following his graduation from Cornell University with a degree in electrical engineering. His experience in the department he now heads has included all phases of engineering: experimental research, product development, testing, and application. He has designed welding machines, electrodes, and fluxes for both manual and automatic welding. The most recent new welding development produced under the direction of Mr. Stringham is a new type of universal welding machine that produces both a-c and d-c welding current. Prior to his appointment as chief engineer in 1951, he was director of welding development where he was responsible for the development of applications for welding processes and equipment. He is also a member of the board of directors of the company. He is a member of the AIEE Electric Welding Committee (1945–49, 1951–55).

F. J. Oliver (AM'47, M'53), editor, *Electrical Manufacturing*, Gage Publishing Company, New York, N. Y., has been elected vice-president of the company. Editor of *Electrical Manufacturing* since 1945, he was previously with the publication *The Iron Age* as machine tool and technical editor. Prior to that he had been associated in an editorial capacity with the *American Machinist*. He is a graduate engineer of the Stevens Institute of Technology and has been engaged in the capacities of application engineer, tester, and machine designer, with such companies as SKF Industries, Inc., General Electric Company, and J. M. Lehman Company. At one time Mr. Oliver served as industrial coordinator, College of Engineering, University of Detroit (Mich.). He is a member of The American Society of Mechanical Engineers.

C. H. Linder (M'54), vice-president, engineering, General Electric Company, New York, N. Y., since 1953, and **H. S. Black** (AM'23, F'41), research engineer, Bell Telephone Laboratories, Inc., Murray Hill, N. J., have been awarded honorary doctor of engineering degrees by Worcester Polytechnic Institute, Worcester, Mass. Mr. Linder was also graduation speaker at the institute's 87th commencement, June 19. He joined General Electric in 1924 as a student engineer after receiving his bachelor's and master's degrees in electrical engineering at the University of Texas. He has been in the administrative phase of both engineering and manufacturing; in consumer goods and heavy apparatus. He was general manager of the Major Appliance Division of General Electric before his election as a vice-president. Mr. Black is a graduate of Worcester Polytechnic. His work with Bell Telephone Laboratories began immediately after his college studies and was predominantly in research on circuits for carrier telephone systems. He invented the stabilized feedback amplifier which is in general use and also in radio, television, and other electronic and communication fields.

R. F. Johnson (AM '39, M '45), contract manager, Missouri office, Evans Electrical Construction Company, Kansas City, Mo., has been elected vice-president of the company. In his new duties he will be responsible for the company's operations in Missouri. The Evans Company does contracting in the electrical construction field with offices in Kansas City, Mo., Kansas City, Kans., and Omaha, Nebr. He is a native of Hamilton, Mo., and graduated from the University of Missouri with a bachelor of science degree in electrical engineering in 1939. For a year and a half he was with Black and Veatch, consulting engineers, and then transferred to the General Electric Company at Fort Wayne, Ind. In 1947 Mr. Johnson joined the Square D Company, Milwaukee, Wis., and was later transferred to the Kansas City district office as field engineer. He is a registered professional engineer in Missouri, Kansas, and Nebraska. He is a member of Tau Beta Pi, Missouri Society of Professional Engineers, and the Electric Association of Kansas City.

E. E. Grazda (AM '42), editor, *Electronic Design*, New York, N. Y., has been elected vice-president of the New York Business Paper Editors Association. Mr. Grazda is a former associate editor of *Electrical Engineering*. At one time he worked for Lincoln Walsh, consulting engineer, Elizabeth, N. J., as an assistant in building experimental and developmental equipment. As assistant editor of *Electronics*, a McGraw-Hill publication, he wrote and edited technical articles, besides reviewing books and literature. His technical education was obtained at the New York University College of Engineering.

M. R. Sitaram (AM'36, M'51), electrical engineer, Government of Mysore, India, is at present touring the United States as an official observer under the Foreign Opera-

tions Administration's exchange personnel program. He is visiting the important hydroelectric installations and transmission systems and exchanging ideas with other electrical engineers. He will be in the United States until the end of the current year. He is a mechanical engineering graduate from the Mysore University, 1931. He specialized in electrical engineering at the Indian Institute of Science, Bangalore, in 1933. Since then he has been working with the Mysore Government's electricity department.

OBITUARIES • • • •

Carl H. Mueller (AM'51), vice-president, Rumsey Electric Company, Philadelphia, Pa., died July 7. He was 60 years of age. He attended the Carnegie Institute of Technology. After graduation he was employed by the Duquesne Light Company and became manager of the test department. He later joined the Lapp Insulator Company, LeRoy, N. Y., as chief of the test department. In 1924 he became affiliated with Harris and Butler, Philadelphia. This company merged with the Rumsey Electric Company in 1935. Mr. Mueller was directly in charge of sales and field engineering in connection with the handling of Delta-Star high-tension switching equipment and Lapp insulators. He became a vice-president of the company in 1950.

Roger R. O'Connor (M '43, F '50), transmission engineer, Illinois Bell Telephone Company, Chicago, Ill., died April 23. Mr. O'Connor was born in Chicago January 2, 1899. He graduated from the University of Illinois with a bachelor of science degree in electrical engineering and then joined the Illinois Bell Telephone Company in 1922. Most of his career with the telephone company was spent studying transmission problems in varying phases for the Bell system. When he first joined the company in July 1922 he was a student engineer, Chicago area engineering department. As part of his rotational training he was transferred to the plant department late in 1922 and worked in various capacities for several years. In 1925 he returned to the chief engineer's office and was given a job in the Transmission Division. He served in various capacities as an engineer until 1928 when he became a supervisor. In 1943 he was appointed transmission engineer for the Chicago area which position he held to the time of his death. Mr. O'Connor was quite active in the AIEE. He served as chairman of various Section committees, becoming treasurer, secretary, and chairman of the Chicago Section. Mr. O'Connor served on the following AIEE committees: Communication (1947–49), Communication Division (1950–51), Wire Communication Systems (1949–55), and Sections (1954–55).

Henry A. Travers (AM'41), technical consultant on calculating boards for Westinghouse Electric Corporation until he retired September 28, 1949, died recently. Mr. Travers graduated from Cornell University in 1906 with a bachelor of science degree in electrical engineering, and entered the Westinghouse graduate student training course that summer. Upon completion of the course he served as switchboard engineer until 1918, when he was made a technical advisor for the Switchgear Division. He served in this capacity until 1927 when he was made technical consultant on calculating board, relay, and system study for the Division. During his assignment as technical advisor he designed the first Westinghouse d-c calculating board for the Takata Company of Japan. Under his leadership, the first Westinghouse a-c calculating board was constructed in 1929 for general use not only by the company, but also for rental to electrical utility companies. On March 26, 1941, Mr. Travers was awarded the Westinghouse Order of Merit, the highest award the corporation bestows on its employees. His award came "for his outstanding ability as a relay and system analyst engineer and for his pioneering work in the development of the network calculator." During his 43 years of service with Westinghouse, he obtained 15 patents on relays, circuit breakers, and electric components for calculating boards. In addition, he supervised the designing of 15 d-c and 16 a-c calculating boards for solution of complicated problems concerning electric systems.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting July 21, 1955, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Alley, W. T., resident engineer, U. S. Army Corps of Engineers, Buford Dam, Ga.
Bairos, C. A., chief inspector, Sacramento Signal Depot, Sacramento, Calif.
Baker, J., electrical engineer, National Acme Co., Cleveland, Ohio
Bechtel, C. B., engineer, Baltimore Gas & Electric Co., Baltimore, Md.
Bellis, M. W., manager, engineering administration I & C E dept., General Electric Co., Erie, Pa.
Benes, E. W., designing electrical engineer, John Paul Jones, Cary & Millar, Cleveland, Ohio
Besch, L. J., quality control supervisor, Westinghouse Electric Corp., Sharon, Pa.
Bhargava, A. N., executive engineer, U. P. Hydel Grid, Roorkee, India
Blokland, J., supervising engineer, S & C Electric Co., Chicago, Ill.
Bomke, E. H., electrical designer, Southern Services, Inc., Birmingham, Ala.
Borgese, A. J., engineer, General Electric Co., Schenectady, N. Y.
Boyles, R. M., electrical engineer, Light Div., City of Tacoma, Wash.
Bredemeier, G. E., intercompany pool engineer, Portland General Electric Co., Spokane, Wash.
Brennan, M. J., consulting engineer, 11 E. 44th St., New York, N. Y.
Bristol, T. R., manager, application engg. power tube subdept., General Electric Co., Schenectady, N. Y.
Brown, J. T. L., member of technical staff, Bell Telephone Labs., Inc., New York, N. Y.
Burr, J. B., General Electric Co., Houston, Tex.
Burrus, G., Jr., electrical supervisor, Stone & Webster Engineering Corp., Richmond, Va.
Chapman, J. J., research contract director, dielectrics lab., The Johns Hopkins University, Baltimore, Md.
Cockrell, J. D., electrical engineer, Light Div., City of Tacoma, Wash.
Corea, E. V., electrical engineer, U. S. Naval Shipyard, Boston, Mass.
Council, J. B., manager, M & R shop, Westinghouse Electric Corp., Houston, Tex.
Crabtree, D. M., electrical engineer, Norfolk Naval Shipyard, Portsmouth, Va.
Dean, C. A., Jr., commercial sales repr., Pacific Gas & Electric Co., Sacramento, Calif.
Dobbs, E. S., senior electrical engineer, Creole Petroleum Corp., Maracaibo, Venezuela
Elam, F. P., apparatus engineer, Line Material Co., Birmingham, Ala.
merson, R. L., job engineer, Bechtel Corp., San Francisco, Calif.
Ertman, R. J., electronic scientist, U. S. Naval Research Lab., Washington, D. C.
Fowler, G. A., director of electronics, Sandia Corp., Albuquerque, N. Mex.
Freeman, C. W., chief engineer, North Electric Co., Galion, Ohio
Frisco, L. J., asst. research contract director, dielectrics lab., The Johns Hopkins University, Baltimore, Md.
Geibel, J. P., design engineer, General Electric Co., Pittsfield, Mass.
Goldsmith, G. J., sales engineer, General Electric Co., Philadelphia, Pa.
Griffee, M. W., chief engineer, The Euclid Electric & Mfg. Co., Madison, Ohio
Hadady, R. E., manager, Field Engg. Div., Ardio & Video Products Corp., Washington, D. C.
Hall, G. L., sales engineer, General Electric Co., Denver, Colo.
Ilgen, L., operations supervisor, Duquesne Light Co., Pittsburgh, Pa.
Jamison, D. H., division engineer, Southwestern Gas & Electric Co., Longview, Tex.
Jones, H. C., senior engineer, Air Arm Div., Westinghouse Electric Corp., Friendship Intl. Airport, Md.
Kennedy, J. A., technical engineer, Brentford Transformers, Ltd., London, England
Koonce, A. M., staff member, Los Alamos Scientific Lab., Los Alamos, N. Mex.
Larose, V. A., head, electrical dept., Holyoke Trade High School, Holyoke, Mass.
Luff, F. T., group engineer, Rural Electrification Administration, Washington, D. C.
Markle, E. W., electrical engg. dept., Texas A & M College, College Station, Tex.
Martin, C. R., Hawley works manager, Allis-Chalmers Mfg. Co., West Allis, Wis.
McDonough, V. T., project engineer, A. D. T. Co., New York, N. Y.
McKay, W. G., asst. administrator & commercial mgr., Greek project, Ebasco Services Inc., New York, N. Y.
Munhall, D. J., western N. Y. mgr., Eagle Signal Corp., Buffalo, N. Y.
Neill, W. A., supervisor, Dow Chemical Co., Freeport, Tex.
Nicolson, E. L., manager-engineering, General Electric Co., Chicago, Ill.
O'Laughlin, M. J., substation engineer, Northern Indiana Public Service Co., Hammond, Ind.
Penn, W. B., technical engineer, General Electric Co., Lynn, Mass.
Polk, H. K., special studies engineer, Public Service Co. of Colorado, Denver, Colo.
Rech, R. H., director, product testing lab., A. O. Smith Corp., Milwaukee, Wis.
Ricci, N. A., electrical system engineer, Wisconsin Electric Power Co., Milwaukee, Wis.
Rossman, P., chief engineer, Eastern area, The Bell Telephone Co. of Pa., Philadelphia, Pa.
Schrader, D. L., plant engineer, Southwest Potash Corp., Carlsbad, N. Mex.
Schultz, A. J., engineering analyst, General Electric Co., Schenectady, N. Y.
Stevens, F. F., manager, industrial sales, General Electric Co., Denver, Colo.
Stroud, W. D., manager, The Okonite Co., New Orleans, La.
Swezea, G. L., engineer, General Electric Co., Richland, Wash.
Tauiman, J. W., Jr., district manager, locke dept., General Electric Co., Dallas, Tex.
Thiemann, V. A., electrical engineer, Ebasco Services, Inc., New York, N. Y.
Vaughan, V. N., Jr., telegraph engineer, American Tel. & Tel. Co., New York, N. Y.
Vosmer, A. L., engineer, General Electric Co., Richland, Wash.
Wagner, M. H., Jr., secretary, The Wagner-Smith Co., Dayton, Ohio
Weissman, S., senior engineer, W. L. Maxson Corp., New York, N. Y.
Williams, C. E., electrical engineer, Armour Research Foundation, Chicago, Ill.
Windham, W. L., Jr., Alabama Power Co., Birmingham, Ala.
Wrenn, W. E., supervising engineer, Westinghouse Electric Corp., Sharon, Pa.
Zemanian, A. H., assistant professor, New York University, New York, N. Y.

71 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before September 25, 1955, or November 25, 1955, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Brown, C. T., Columbia-Southern Chemical Corp., Corpus Christi, Tex.
Moline, G. A., Canadian Westinghouse Co., Ltd. Hamilton, Ont., Canada
Roe, K. A., Burns & Roe Inc., New York, N. Y.
Speakman, E. A., Fairchild Guided Missiles Div., Wyandanch, N. Y.
Welch, H. W., Jr., University of Michigan, Ann Arbor, Mich.

5 to grade of Member

AIEE Officers and Committees for 1955-56

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M. D. HOOVEN
Newark, N. J.
(Term expires July 31, 1956)

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(Term expires July 31, 1956)

A. C. MONTEITH, Pittsburgh, Pa.
(Term expires July 31, 1957)

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9 J. R. WALKER, Billings, Mont.
11 J. C. STRASBOURGER, Cleveland, Ohio
(Terms expire July 31, 1956)

District
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8 BRADLEY COZZENS, Los Angeles, Calif.
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(Terms expire July 31, 1957)

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(Terms expire July 31, 1956)
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T. M. LINVILLE, Schenectady, N. Y.
E. W. SEEGER, Milwaukee, Wis.
(Terms expire July 31, 1957)

L. F. HICKERNELL, Hastings-on-Hudson, N. Y.
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(Terms expire July 31, 1958)
J. D. TEBO, New York, N. Y.
P. G. WALLACE, Dallas, Tex.
J. C. WOODS, Chicago, Ill.
(Terms expire July 31, 1959)

TREASURER

WALTER J. BARRETT, Newark, N. J.
(Term expires July 31, 1956)

SECRETARY

N. S. HIBSHMAN, New York, N. Y.
(Term expires July 31, 1956)

LOCAL HONORARY SECRETARIES

AUSTRALIA—V. J. F. Brain, Electricity Authority of N.S.W., Box 2600 G.P.O., Sidney, New South Wales

BRAZIL—W. L. Simpson, São Paulo Light and Power Company, Caixa Postal 8026, São Paulo

ENGLAND—Sir A. P. M. Fleming, Metropolitan Vickers Electric Company, Trafford Park, Manchester 17

INDIA, NORTHERN—S. S. Kumar, Utilization Member, Central Water & Power Commission, Bikaner House, New Delhi

INDIA, SOUTHERN—C. S. Ghosh, Indian Institute of Science, Bangalore 3

IRELAND—Gerard M. Mulhern, Transmission Dept., Electricity Supply Board, 27 Lower Fitzwilliam Street, Dublin

JAPAN—Hisagoro Mori, 32 Kawanishi Cho, Ashiya City

NEW ZEALAND—T. R. Pollard, Canterbury University College, Box 1152, Christchurch (Acting)

PAKISTAN—Mohamed Hussain Khalid, Executive Engineer, Electricity, D. I. Khan, N.W.F.

SWEDEN—Edy Velander, Box 5073, Stockholm 5

TRANSVAAL—Francis E. Ingham, Post Box 8605, Johannesville, South Africa

General Committees

Executive

M. D. Hooven, *Chairman;* Public Service Elec. & Gas Co., 80 Park Place, Newark 1, N. J.
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L. F. Hickernell, Hastings-on-Hudson, N. Y.
T. M. Linville, Schenectady, N. Y.
A. C. Monteith, Pittsburgh, Pa.
C. S. Purnell, Los Angeles, Calif.
Elgin B. Robertson, Dallas, Tex.

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J. B. MacLean, New York, N. Y.
E. C. Molina, East Orange, N. J.
H. P. St. Clair, New York, N. Y.
E. V. Sayles, Jackson, Mich.
H. W. Tenney, Jersey City, N. J.
Gordon Thompson, New York, N. Y.
H. M. Trueblood, Dobbs Ferry, N. Y.
B. Van Ness, Jr., Allentown, Pa.
R. G. Warner, New Haven, Conn.
S. S. Watkins, New York, N. Y.
Ernst Weber, Brooklyn, N. Y.
E. P. Yerkes, Philadelphia, Pa.

Charles LeGeyt Fortescue Fellowship

E. T. B. Gross, Arlington Heights, Ill.
G. E. Moore, *Chairman*, East Pittsburgh, Pa.
(Terms expire July 31, 1956)
N. B. Ames, Washington, D. C.
J. H. Lampe, Raleigh, N. C.
(Terms expire July 31, 1957)
J. F. Calvert, Pittsburgh, Pa.
E. S. Fields, Cincinnati, Ohio
(Terms expire July 31, 1958)

Code of Principles of Professional Conduct

P. L. Alger, *Chairman;* 1758 Wendell Ave., Schenectady, N. Y.
R. E. Argersinger, *Vice-Chairman* — Boston, Mass.
L. G. Gitzendanner, *Secretary* — Schenectady, N. Y.
H. W. Bibber — Schenectady, N. Y.
D. I. Cone — San Francisco, Calif.
M. S. Coover — Ames, Iowa
W. C. Du Vall — Boulder, Colo.
G. D. Edwards — New York, N. Y.
R. L. Goetzenberger — Washington, D. C.
C. A. Heinze — Los Angeles, Calif.
A. H. Kidder — Philadelphia, Pa.
W. J. Morrill — Fort Wayne, Ind.
E. J. Thomas — Fort Wayne, Ind.

Constitution and Bylaws

E. S. Lammers, Jr., *Chairman;* Westinghouse Electric Corp., 1299 Northside Drive, N.W., Atlanta, Ga.
C. Dusenbury, *Secretary* — Atlanta, Ga.
D. D. Ewing — Lafayette, Ind.
J. Harold Karr — Springfield, Ohio
W. W. Lewis — Schenectady, N. Y.
W. S. Peterson — Los Angeles, Calif.
P. G. Wallace — Dallas, Tex.

Edison Medal

Appointed by the President for term of five years

A. H. Frampton — Toronto, Ont., Canada
J. R. North — Jackson, Mich.
B. R. Teare, Jr. — Pittsburgh, Pa.
(*Terms expire July 31, 1956*)
O. B. Blackwell — Plandome, N. Y.
J. F. Fairman — New York, N. Y.
E. P. Yerkes, *Chairman* — Philadelphia, Pa.
(*Terms expire July 31, 1957*)
S. S. Attwood — Ann Arbor, Mich.
Charles F. Wagner — East Pittsburgh, Pa.
P. G. Wallace — Dallas, Tex.
(*Terms expire July 31, 1958*)
R. Cutts, Jr., *Secretary* — Schenectady, N. Y.
J. D. Harper — Rockdale, Tex.
Elgin B. Robertson — Dallas, Tex.
(*Terms expire July 31, 1959*)
A. C. Monteith — Pittsburgh, Pa.
J. D. Ryder — East Lansing, Mich.
F. O. Schnure — Sparrows Point, Md.
(*Terms expire July 31, 1960*)

Members of the Board of Directors elected by the Board for term of 2 years

L. F. Hickernell — Hastings-on-Hudson, N. Y.
A. C. Muir — Philadelphia, Pa.
E. W. Seeger — Milwaukee, Wis.
(*Terms expire July 31, 1956*)
Bradley Cozens — Los Angeles, Calif.
J. H. Foote — Jackson, Mich.
T. M. Linville — Schenectady, N. Y.
(*Terms expire July 31, 1957*)

Education

Guy Kleis, *Chairman;* Westinghouse Electric Corp., East Pittsburgh, Pa.
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E. M. Williams, *Secretary* — Pittsburgh, Pa.
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I. B. Baccus — East Lansing, Mich.
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D. S. Bridgman — New York, N. Y.
E. M. Brohl — Flint, Mich.
J. F. Calvert — Pittsburgh, Pa.
P. T. Coffin — Pittsburgh, Pa.
M. S. Coover — Ames, Iowa
J. Gammell — West Allis, Wis.
F. Hamburger, Jr. — Baltimore, Md.
H. E. Hartig — Minneapolis, Minn.
A. R. Hellwarth — Detroit, Mich.
G. A. Irland — Lewisburg, Pa.
J. S. Johnson — Lafayette, Ind.
R. J. W. Koopman — St. Louis, Mo.
J. H. Lampe — Raleigh, N. C.
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T. C. Lloyd — Springfield, Ohio
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J. A. M. Lyon — Evanston, Ill.
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H. A. Peterson — Madison, Wis.
J. D. Ryder — East Lansing, Mich.
W. J. Seeley — Durham, N. C.
H. H. Skilling — Stanford, Calif.
E. F. Smith — Gainesville, Fla.
L. N. Stone — Corvallis, Oreg.
E. M. Strong — Ithaca, N. Y.
B. R. Teare, Jr. — Pittsburgh, Pa.
G. S. Timoshenko — Storrs, Conn.
G. F. Tracy — Toronto, Ont., Canada
S. Reid Warren, Jr. — Philadelphia, Pa.

Finance

J. P. Neubauer, *Chairman;* Consolidated Edison Co. of N. Y., Inc., 4 Irving Place, New York 3, N. Y.
T. M. Linville — Schenectady, N. Y.
J. D. Tebo — New York, N. Y.

Headquarters

L. F. Stone, *Chairman;* General Electric Co., 744 Broad St., Newark 2, N. J.
J. R. Kerner — New York, N. Y.
J. P. Neubauer — New York, N. Y.

Lamme Medal

O. S. Hockaday — Fort Worth, Tex.
J. T. O'Halloran, *Secretary* — AIEE Headquarters
J. J. Pilliod, *Chairman* — Scarsdale, N. Y.
E. W. Seeger — Milwaukee, Wis.
(*Terms expire July 31, 1956*)
E. W. Engstrom — Princeton, N. J.
M. H. Hobbs — East Pittsburgh, Pa.
C. T. Sinclair — Pittsburgh, Pa.
(*Terms expire July 31, 1957*)
C. W. Franklin, *Vice-Chairman* — New York, N. Y.
D. S. Roberts — West Lynn, Mass.
H. I. Romnes — New York, N. Y.
(*Terms expire July 31, 1958*)

Management

L. R. Gaty, *Chairman;* Philadelphia Electric Co., 1000 Chestnut St., Philadelphia 5, Pa.
H. B. Kiphuth, *Vice-Chairman* — Pittsburgh, Pa.
W. F. Henn, *Secretary* — Philadelphia, Pa.
E. D. Ayres — Columbus, Ohio
W. C. Bell — New Haven, Conn.
C. J. Beller — Cleveland, Ohio
Walter Brenton — Portland, Oreg.
W. H. Chase — Cleveland, Ohio
L. W. Clark — Detroit, Mich.
R. Cutts, Jr. — Schenectady, N. Y.
W. J. Ellenberger — Washington, D. C.
H. H. Grant — Los Angeles, Calif.
N. B. Guthett — Des Moines, Iowa
H. O. Hodson — Amarillo, Tex.
E. E. Johnson — Schenectady, N. Y.
S. A. Langell — Canton, Ohio
R. W. Larson — Schenectady, N. Y.
F. K. McCune — Schenectady, N. Y.
W. J. Morrill — Fort Wayne, Ind.
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Name	District	When Organized	Chairman	Secretary	Secretary's Address
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Alabama	4	May 22, '29	R. E. Williams, Jr.	W. R. Booth	Southern Bell Tel. & Tel. Co., 316 Phoenix Bldg., Birmingham, Ala.
Arizona	8	Mar. 22, '41	R. H. Hartley	W. E. Garity	General Electric Co., 303 Luhrs Tower, Phoenix, Ariz.
Arkansas	7	Apr. 23, '47	Kenneth Johnson	H. J. Owen	
Arrowhead	5	Apr. 23, '47	V. M. Sovick	J. E. Abramson	Duluth, Missabe & Iron Range Railway Co., 403 Wolvin Bldg., Duluth 2 Minn.
Baton Rouge	4	Feb. 3, '55	D. H. Hovey	M. B. Reed	Dept. of Elec. Engg., Louisiana State University, Baton Rouge, La.
Beaumont	7	June 27, '45	H. J. Sutton	J. D. Moriaty	Gulf Oil Corp., Port Arthur, Tex.
Boston	1	Feb. 13, '03	C. W. Maloney	H. W. Evirs, Jr.	Fitchburg Gas & Elec. Light Co., 89 Broad St., Boston 10, Mass.
Canton	11	Nov. 5, '47	G. W. Steffen	R. T. Trier	302 Cordelia Road, North Canton, Ohio
Central Illinois	5	June 28, '51	G. E. Sangster	J. W. Marquardt	322 1-3 East Adams St., Springfield, Ill.
Central Indiana	5	Jan. 12, '12	E. E. Sterner	T. W. Metz	Allis-Chalmers Mfg. Co., 1604 Merchants Bank Bldg., Indianapolis 4, Ind.
Chicago	5	1893	R. G. Gear	E. R. Whitehead	Illinois Inst. of Tech., 3300 South Federal St., Chicago 16, Ill.
Cincinnati	11	June 30, '20	A. C. Herweh	W. H. Middendorf	Dept. of Elec. Engg. University of Cincinnati, Cincinnati, Ohio
Cleveland	11	Sept. 27, '07	G. R. Canning	K. L. Wheeler	Cleveland Electric Ill. Co., 75 Public Square, Cleveland 1, Ohio
Columbus	11	Mar. 17, '22	W. E. Best	F. C. Weimer	Dept. of Elec. Engg., Ohio State Univ., Columbus 10, Ohio
Connecticut	1	Apr. 16, '21	M. B. Sprague	F. W. Engster	General Electric Co., 129 Church St., New Haven 10, Conn.
Corpus Christi	7	Oct. 25, '51	O. A. Boyer	Floyd Salmon	Central Power & Light Co., 120 North Chaparral St., Corpus Christi, Tex.
Dayton	11	June 9, '43	D. N. Warren	W. R. Jacox	634 Third Nat'l. Bank Bldg., Dayton 2, Ohio
Delaware Bay	2	June 1, '52	C. S. Rankin	C. G. Tarkenton	Delaware Power & Light Co., 600 Market St., Wilmington, Del.
Denver	6	May 18, '15	A. E. Paige	H. P. Deming	Stearns-Roger Mfg. Co., 660 Bannock St., Denver, Colo.
East Tennessee	4	Sept. 2, '36	Volney J. Cisna	Frank W. Smith	Tennessee Valley Authority, Chattanooga, Tenn.
El Paso	7	Mar. 7, '40	C. C. Homan, Jr.	H. L. Penley	El Paso Electric Co., El Paso, Tex.
Erie	2	Jan. 11, '18	C. G. Moon	T. J. Warrick	General Electric Co., Erie, Pa.
Fort Wayne	5	Aug. 14, '08	D. F. Wartzok	Andrew Schevtchuk	2120 N. Anthony Blvd., Fort Wayne, 3 Ind.
Georgia	4	Jan. 14, '04	J. C. Ager	J. F. Willett	Westinghouse Electric Corp., 1299 Northside Drive, Atlanta, Ga.
Hamilton	10	May 1, '53			
Hawaii	8	June 24, '54	J. M. Lynd	R. P. Passy	930 Clayton St., Honolulu, Hawaii
Houston	7	Aug. 7, '28	H. J. Kongabel	M. T. Robin	Houston Lighting & Power Co., P. O. Box 1700, Houston 1, Tex.
Illinois Valley	5	June 30, '45	Elmer Keefling	R. S. McCready	Central Illinois Light Co., 316 South Jefferson, Peoria, Ill.
Iowa	5	June 29, '29			
Iowa-Illinois	5	June 24, '54	E. M. Miller	W. E. Keefe	General Electric Co., 511 Pershine Ave., Davenport, Iowa
Ithaca	1	Oct. 15, '02	D. J. Bechtold	C. J. Fitch	International Business Machines Corp., Endicott, N. Y.
Jacksonville	4	Jan. 28, '31	W. T. Sams	J. M. Wright	Turner Electric Works, 1020 E. 8th St., Jacksonville, Fla.
Johnstown	2	Apr. 14, '55	G. W. Murdock	R. D. Good	Pennsylvania Electric Co., 222 Levergood St., Johnstown, Pa.
Kansas City	7	Apr. 14, '16	D. A. Starcke	Roy M. Gear	Black & Veatch, 4706 Broadway, Kansas City, Mo.
Lehigh Valley	2	Apr. 16, '21	S. C. Townsend	F. S. Fehr	Metropolitan Edison Co., P. O. Box 542, Reading, Pa.
Lima	11	June 24, '54	H. B. James	R. E. Klokon	
Los Angeles	8	May 19, '08	W. S. Peterson	H. A. Lott	Southern California Edison Co., 601 W. 5th St., Los Angeles, Calif.
Louisville	4	Oct. 15, '26	J. F. Gregory	W. J. Ryan	4215 North Western Parkway, Louisville 12, Ky.
Lynn	1	Aug. 22, '11	S. W. Stawicki	D. M. Longenecker	
Madison	5	Jan. 8, '09	M. J. Spooner	D. K. Reitan	Dept. Elec. Engg., University of Wisconsin, Madison, Wis.
Maine	1	June 30, '55	H. W. Murdock	Basil Payne	Central Maine Power Co., 9 Green St., Augusta, Maine
Mansfield	11	Mar. 6, '39	C. J. Andrews	C. C. Crow	North Electric Mfg. Co., Galion, Ohio
Maryland	2	Dec. 16, '04	W. B. Mann	T. E. Marburger	Consolidated Gas, Electric Light & Power Co. of Baltimore, Lexington Bldg., Baltimore 3, Md.
Memphis	4	May 22, '30	Claude Young	G. C. Davies	Arkansas Power & Light Co., Forrest City, Ark.
Mexico	7	June 29, '22	Hector Martinez D'Meza		
Miami	4	Feb. 3, '49	F. B. Lucas	R. H. Stevens	830 North West 84th Terrace, Miami, Fla.
Michigan	5	Jan. 13, '11	H. R. Armstrong	F. Von Voightlander	1919 Wayne St., Ann Arbor, Mich.
Milwaukee	5	Feb. 11, '10	J. A. Deubel	R. J. Ungrodt	Milwaukee School of Engg., 1020 N. Broadway, Milwaukee, Wis.
Minnesota	5	Apr. 7, '02	J. J. Rudolf	S. N. Witta	Northern States Power Co., 15 South 5th St., Minneapolis 2, Minn.
Mississippi	4	June 28, '51	T. M. Salisbury	N. L. Stampley	Mississippi Power & Light Co., Jackson, Miss.
Mobile-Pensacola	4	Jan. 22, '53	L. A. McGraw	J. G. Pride	Alabama Power Co., Mobile, Ala.
Montana	9	June 24, '31	R. J. Carlson	W. R. Duffy	1914 Howard St., Butte, Mont.
Montreal	10	Apr. 16, '43	D. King	D. T. Shaw	Reliance Elec. & Engrg. (Canada) Ltd.,1179 Decarie Blvd., Montreal, Que., Canada
Nashville	4	June 28, '51	W. C. Raiford	R. D. Bourne	P. O. Box 1570, Station B., Vanderbilt University, Nashville, Tenn.
Nebraska	6	Jan. 21, '25	O. H. Brand	W. A. Richardson	Henningson, Durham & Richardson, Inc., 2962 Harney St., Omaha 2, Nebr.
New Hampshire	1	Sept. 3, '53	L. M. Partridge	R. A. Nichols	Public Service Co. of N. H., 1087 Elm St., Manchester, N. H.
New Orleans	4	Dec. 8, '33	M. W. Stumpf	W. S. Jones	Rockbestos Products Corp., 254 Inter'n. Trade Mart, New Orleans, La.
New York	3	Dec. 10, '19	R. T. Weil	R. W. Gillette	Consolidated Edison Co. of N. Y., Inc., 4 Irving Place, New York 3, N. Y.

Niagara Frontier	1	Feb. 10, '25	R. A. Beuerman	V. A. Leitzke	General Electric Co., 535 Washington St., Buffalo 3, N. Y.
Niagara International	10	Aug. 5, '48	P. W. Shill	S. C. Roberts	Packard Electric Co., St. Catharines, Ont., Canada
North Carolina	4	Mar. 21, '29	K. T. Knight	E. W. Winkler	North Carolina State College, Raleigh, N. C.
Northeastern Michigan	5	Feb. 2, '50	G. S. Marvin	F. W. Inman	Chevrolet, Saginaw Grey-Iron Foundry, Saginaw, Mich.
Northern New Mexico	7	Jan. 25, '51	H. M. Hayes	J. E. Ansley	1828 Wildwood Lane S. W., Albuquerque, N. Mex.
North Texas	7	May 18, '28	C. A. Maas	J. B. Robuck	Texas Power & Light Co., Dallas, Tex.
Oak Ridge	4	Feb. 1950	E. A. Crow	J. C. Haydon	Roane-Anderson Co., Oak Ridge, Tenn.
Ohio Valley	11	June 28, '51	H. H. Kincaid	F. R. Willoughby	Westinghouse Elec. Corp., Huntington, W. Va.
Oklahoma City	7	Feb. 16, '22	F. W. Fullerton	G. E. Brooks	Oklahoma Gas & Electric Co., P. O. Box 1498, Oklahoma City, Okla.
Ottawa	10	June 23, '49	R. H. McCabe	E. W. Humphrys	N. W. Territories Power Comm., 150 Wellington St., Ottawa, Ont., Canada
Panhandle Plains	7	June 12, '47	C. W. Gragg	L. L. Davis	Box 631, Borger, Tex.
Philadelphia	2	Feb. 18, '03	T. E. Stieber	G. B. Schleicher	Philadelphia Electric Co., 2301 Market St., Philadelphia 3, Pa.
Pittsburgh	2	Oct. 3, '02	L. J. Berberich	R. N. Wagner	Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh, Pa.
Pittsfield	1	Mar. 25, '04	G. L. Vallin	A. F. Rohlfs	General Electric Co., 100 Woodlawn Ave., Pittsfield, Mass.
Portland	9	May 18, '09	R. R. Bracchi	J. G. Kirwin	
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Ridgway	2	June 26, '52			
Rochester	1	Oct. 9, '14	H. A. Brown	L. C. Holmes	Stromberg-Carlson Co., 100 Carlson Road, Rochester 3, N. Y.
Rock River Valley	5	Apr. 23, '47	O. L. Welker	T. C. Cameron	Sundstrand Machine Tool Co., Rockford, Ill.
Sacramento	8	June 15, '50	M. N. Davies	E. C. Sparrow, Jr.	Maloney Electric Co., 5390 Bircher Blvd., St. Louis 20, Mo.
St. Louis	7	Jan. 14, '03	E. E. Gilcrease	W. J. Roa, Jr.	Sverdrup & Parcel Inc., Syndicate Trust Bldg., St. Louis 1, Mo.
St. Maurice Valley	10	June 24, '54	A. P. Earle	W. G. Seline	3450 Duvernay St., Trois Rivieres, Que., Canada
San Diego	8	Jan. 18, '39	E. B. Love	B. A. Weiss	Imperial Irrigation District, Imperial, Calif.
San Francisco	8	Dec. 23, '04	W. Ridgway	C. F. Dalziel	Dept. of Elec. Engg., University of Calif., Berkeley 4, Calif.
Savannah	4	Oct. 14, '54	C. O. Du Rant	M. T. McKenzie	Route 6—Box 176, Isle of Hope, Savannah, Ga.
Schenectady	1	Jan. 26, '03	R. K. Fairley	D. H. Ware	General Electric Co., 1 River Road, Schenectady 5, N. Y.
Seattle	9	Jan. 19, '04	H. R. Loew	R. W. Illman	Boeing Aircraft Co., Seattle, Wash.
Sharon	2	Dec. 11, '25	Saul Bennon	G. Hattrup	Westinghouse Electric Corp., Sharon, Pa.
Shreveport	7	June 12, '47	L. C. Barry	R. G. Flowers, Jr.	Sklar Bldg., Room 910, Shreveport, La.
South Bend	5	Feb. 26, '41	J. M. Evans	R. C. Emery	General Electric Co., National Bank Bldg., Room 507, South Bend, Ind.
South Carolina	4	Mar. 2, '40	D. T. Coleman	M. W. Cole, Jr.	P. O. Box 5273, North Charleston, S. C.
South Texas	7	May 23, '30	Harold Robinson	T. A. Dodson	P. O. Box 125, Austin, Tex.
Spokane	9	Feb. 14, '14	N. H. Meyers	R. D. Brown	Allis Chalmers Mfg. Co., 804 Old National Bldg., Spokane, Wash.
Springfield	1	June 29, '22	A. G. Payne	C. L. Hopkins	Line Material Co., Agawam, Mass.
Susquehanna	2	June 18, '53	M. H. Keiffer	G. S. Pomeroy III	Metropolitan Edison Co., 700 Chestnut St., Lebanon, Pa.
Syracuse	1	Aug. 12, '20	J. W. Becker		
Tampa	4	Feb. 1, '52			
Toledo	11	June 3, '07	R. E. Warren	C. E. Campbell	Emery Marker & Campbell, 1408 Toledo Trust Bldg., Toledo 4, Ohio
Toronto	10	Sept. 30, '03	G. F. Tracy	V. B. Ross	Canadian General Electric Co., 212 King St., West, Toronto, Ont., Canada
Tulsa	7	Oct. 1, '37	R. D. Bennett	W. B. Nesbitt	Public Service Co. of Okla., Tulsa, Okla.
Utah	9	Mar. 9, '17	V. E. Clayton	R. E. Stephenson	
Vancouver	9	Aug. 22, '11	J. T. Turner	G. J. Henrickson	B. C. Electric Co. Ltd., 425 Carroll St., Vancouver 4, B. C., Canada
Virginia	4	May 19, '22	W. T. Stone	W. P. Molette	General Electric Co., 700 East Franklin St., Richmond 17, Va.
Virginia Mountain	4	June 23, '49	J. S. Jamison, Jr.	E. C. Rankin	Appalachian Electric Power Co., 40 Franklin St., Roanoke, Va.
Washington	2	Apr. 9, '03	J. O. Pease	D. K. Steidinger	Allis Chalmers Mfg. Co., 717 Wyatt Bldg., Washington 5, D. C.
West Michigan	5	June 24, '54	William Wingler	H. Thomas Stowitts	
West Virginia	11	Apr. 9, '40	R. H. Hively	Paul W. Sinsel	Chesapeake & Potomac Tel. Co., 816 Lee St., Charleston, W. Va.
Wichita	7	Sept. 16, '37	Ralph Longstaff	C. S. Clark	General Electric Co., 200 E. 1st St., Wichita, Kans.
Worcester	1	Feb. 18, '20	D. Jack Allia	W. J. Creighton	General Electric Co., 288 Grove St., Worcester 5, Mass.
Total Sections	109				

Subsections

Name	Chairman	Secretary	Secretary's Address
Adirondack (Schenectady Section)	W. O. Solberg	R. E. Gratton	General Electric Co., Capacitor Dept., Hudson Falls, N. Y.
Atlantic City Division (Philadelphia Section)			
Billings (Montana Section)	W. S. Wheeler	C. R. Beitman	U. S. Bureau of Reclamation, Billings, Mont.
Binghamton Area (Ithaca Section)	A. O. Kenyon	D. Florance	Florance Electric Supply Co., Inc., 13 S. Washington St., Binghamton, N. Y.
Black Hills (Denver Section)	E. E. Clark	William Hixson	Elec. Engg. Dept., South Dakota School of M&T, Rapid City, S. Dak.
Boise (Utah Section)	Joseph Devine	C. N. Teed	Idaho Power Co., P. O. Box 770, Boise, Idaho
Boulder City (Los Angeles Section)	F. L. Long, Jr.	G. L. Barneby	Water & Power Dept., City of Los Angeles, Boulder City, Nev.
Casper Wyo. (Denver Section)			
Central Savannah (South Carolina Section)	R. S. Carter, Jr.	L. Ellison, Jr.	1818 Oriole Drive, North Augusta, Ga.
Central Texas (North Texas Section)			
Centre County (Pittsburgh Section)	P. X. Rice	R. M. Hoover	Ordinance Research Lab., The Pennsylvania State University, University Park, Pa.
Charleston (South Carolina Section)	J. R. Dickson	D. A. Springs	South Carolina Public Service Authority, Moncks Corner, S. C.
Charlotte (North Carolina Section)	J. G. Alexander	J. J. Greagan, Jr.	Allis-Chalmers Mfg. Co., 1014 Johnston Bldg., Charlotte, N. C.
Chillicothe (Columbus Section)	J. E. Hinkle	J. M. Yarbrough	Mead Corp., Chillicothe, Ohio
Columbia (South Carolina Section)	A. J. Perrone, Jr.	J. M. McDonald	General Electric Co., Columbia, S. C.
Eastern Division (St. Louis Section)	Floyd Mitchell	Thomas Harmon	Granite City Steel Co., Granite City, Ill.
Eastern Idaho (Utah Section)			
Eastern North Carolina (North Carolina Section)	E. K. Kraybill	E. G. Manning	North Carolina State College, Raleigh, N. C.
Eastern Shore (Maryland Section)	R. G. Pearson	R. R. Jefferson	Delaware Electric Cooperative, Inc., Greenwood, Del.
Eugene (Portland Section)	R. E. Carlson	H. D. Axtell	46 Happy Lane, Eugene, Oreg.
Fort Worth (North Texas Section)			
Fox River Valley (Milwaukee Section)			
Freeport (Houston Section)			
Fresno Division (San Francisco Section)	Jack Girven	E. R. Tomblin	General Electric Co., 407 Patterson Bldg., Fresno, Calif.
Great Falls (Montana Section)			
Hampton Roads (Virginia Section)	D. J. Ball	Mrs. K. O. Joyner	168 Victoria Ave., Hampton, Va.
Hudson Valley Division (New York Section)			
Huntsville (East Tennessee Section)	R. T. Gambil, Jr.	M. A. Kalange	210 Parklane Ave., Huntsville, Ala.
Lake Charles (Beaumont Section)			
Lexington (Louisville Section)			
London (Hamilton Section)			
Los Alamos-Santa Fe (Northern New Mexico Section)			
Marion (Fort Wayne Section)			
Medford (Portland Section)	J. W. Crawford	L. M. Stinson	626 W. 4th St., Medford, Oreg.
Mid-State (North Carolina Section)	M. J. Mulhern	M. D. Haines	Western Electric Co., Dept. 82, Lexington Road, Winston-Salem, N. C.
Monroe (Shreveport Section)			
Montgomery (Alabama Section)			
Muscle Shoals (East Tennessee Section)	C. W. Riley	E. M. Crum	Reynolds Alloys Co., Sheffield, Ala.
New Jersey Division (New York Section)	P. A. Ward	M. T. Whiting	Public Service Electric & Gas Co., 80 Park Place, Newark, N. J.
Northwest Arkansas (Arkansas Section)	H. K. Hubenthal	J. M. McConnell	Southwestern Bell Telephone Co., 101 North 13th St., Fort Smith, Ark.
Northwest Iowa (Iowa Section)	C. U. Osburn	Paul M. Anderson	Iowa Public Service Co., Orpheum-Electric Bldg., Sioux City, Iowa
Paducah (Louisville Section)			
Piedmont (South Carolina Section)	A. B. Hinson	A. E. Blair	214 Henderson St., Greenville, S. C.

Quebec (Montreal Section)	Lionel Swift	Gaston Galibois	Quebec Power Co., 399 St. Joseph St. East, Quebec, Que., Canada
Racine-Kenosha (Milwaukee Section)			
Red River Valley Division (Minnesota Section)	Charles Randall	Dean Jacobson, Jr.	420 East Vernon, Fergus Falls, Minn.
Reno (San Francisco Section)	W. L. McCabe	W. L. Garrott	Dept. of Elec. Engg., University of Nevada, Reno, Nev.
Richmond (Virginia Section)	C. M. Stallings	M. S. Spicer	Chesapeake & Potomac Tel. Co. of Va., 703 E Grace St., Richmond, Va.
Riverside-San Bernardino (Los Angeles Section)	G. C. Able	C. N. Parker	3274 Redwood Drive, Riverside, Calif.
St. Lawrence International (Syracuse Section)	P. Nevaldine	T. Simpkins	8 Prospect Drive, Massena, N. Y.
San Jose (San Francisco Section)	E. L. Kastainsek	F. C. Buchholz	86 S. Third St., San Jose, Calif.
Scioto Valley (Ohio Valley Section)	P. W. Meadows	J. M. Duncan	Goodyear Atomic Corp., 1434 Bihlman Dr., Portsmouth, Ohio
Shasta Division (San Francisco Section)	T. D. Martin	W. G. Schrader	U. S. Bureau of Reclamation, P. O. Box 207, Redding, Calif.
Southern Colorado (Denver Section)			
Tacoma (Seattle Section)	B. C. West	Carl Staff	Weyerhaeuser Timber Co., Tacoma, Wash.
Tullahoma (East Tennessee Section)	R. C. Carter, Jr.	C. B. Chadwick	General Delivery, Tullahoma, Tenn.
Vancouver Island (Vancouver Section)	A. E. Ross	A. Thonimasen	385 Arnat Avenue, Victoria, B. C., Canada
Vermont (Pittsfield Section)	W. M. Edson	E. M. Palmer	General Electric Co., Lakeside Ave., Burlington, Vt.
Wenatchee (Spokane Section)	R. V. Wachter	S. A. Nelson	General Electric Co., P. O. Box 676, Wenatchee, Wash.
West Central Texas Division (North Texas Section)	J. A. Hutchinson	R. G. Meador	West Texas Utilities Co., Abelene, Tex.
Western North Carolina (North Carolina Section)	J. Hunter	R. W. Kirby	American Enka Corporation, Enka, N. C.
Zanesville (Columbus Section)	W. N. Bovenizer	F. A. Hatfield	Line Material Co., Zanesville, Ohio

Total Subsections 62

Student Branches

Name and Location	District	Counselor (Member of Faculty)
*Akron, University of, Akron, Ohio	11	Kenneth F. Sibila
Alabama Polytechnic Institute, Auburn	4	Albert T. Sprague, Jr.
Alabama, University of, University	4	W. F. Gray
*Alberta, University of, Edmonton, Canada	10	R. E. Phillips
*Arizona, University of, Tucson	8	J. L. Knickerbocker
*Arkansas, University of, Fayetteville	7	D. D. Lingelbach
*British Columbia, University of, Vancouver, Canada	9	L. R. Kersey
*Brooklyn, Polytechnic Institute of, Brooklyn, N. Y., (Day)	3	F. A. Wahlers
*Brooklyn, Polytechnic Institute of Brooklyn, N. Y., (Evening)	3	F. G. Van Note
*Brown University, Providence, R. I.	1	
*Bucknell University, Lewisburg, Pa.	2	Raymond Young
*California Institute of Technology, Pasadena	8	C. H. Wilts
*California, University of, Berkeley	8	H. C. Bourne
*Carnegie Institute of Technology, Pittsburgh, Pa.	2	A. T. Murphy
Case Institute of Technology, Cleveland, Ohio	11	N. E. Prochaska
Catholic University of America, Washington, D. C.	2	J. C. Michalowicz
*Cincinnati, University of, Cincinnati, Ohio	11	C. F. Evert, Jr.
Clarkson College of Technology, Potsdam, N. Y.	1	
Clemson A & M College, Clemson, S. C.	4	F. T. Tingley
*Colorado A & M College, Fort Collins	6	P. H. Lindon
*Colorado, University of, Boulder	6	S. I. Pearson
*Columbia University, New York, N. Y.	3	Gene Franklin
*Connecticut, University of, Storrs	1	
*Cooper Union, New York, N. Y.	3	Matthew E. Zaret
*Cornell University, Ithaca, N. Y.	1	Norman Vrana
*Dayton, University of, Dayton, Ohio	11	L. H. Rose
*Delaware, University of, Newark, Del.	2	H. S. Bueche
*Denver, University of, Denver, Colo.	6	A. E. Paige
*Detroit, University of, Detroit, Mich.	5	R. W. Ahlquist
*Drexel Institute of Technology, Philadelphia, Pa.	2	F. C. Powell
Duke University, Durham, N. C.	4	H. A. Owen, Jr.
Fenn College, Cleveland, Ohio	11	R. W. Schindler
*Florida, University of, Gainesville	4	L. F. Schoonmaker
†Gannon College, Erie, Pa.	2	
*George Washington University, Washington, D. C.	2	D. J. Hanrahan
Georgia Institute of Technology, Atlanta	4	E. R. Weston
†Houston, University of, Houston, Tex.	7	T. N. Whitaker
Howard University, Washington, D. C.	2	E. R. Welch
Idaho, University of, Moscow	9	W. R. Parish
Illinois Institute of Technology, Chicago	5	B. A. Fisher
*Illinois, University of, Urbana, and Chicago Division, Chicago	5	J. E. Williams
*Iowa State College, Ames	5	G. A. Richardson
Iowa, University of, Iowa City	5	E. B. Kurtz
*Johns Hopkins University, Baltimore, Md.	2	Thorstein Larsen
Kansas State College, Manhattan	7	E. L. Sitz
*Kansas, University of, Lawrence	7	W. P. Smith
Kentucky, University of, Lexington	4	G. E. Smith
*Lafayette College, Easton, Pa.	2	F. W. Smith
†Lamar State College of Technology, Beaumont, Tex.	7	L. B. Cherry
Laval University, Quebec, Canada	10	Maurice Boisvert
Lehigh University, Bethlehem, Pa.	2	Joseph Teno
Louisiana Polytechnic Institute, Ruston	7	M. R. Johnson
*Louisiana State University, Baton Rouge	4	M. B. Reed
*Louisville, University of, Louisville, Ky.	4	M. G. Northrop
*Maine, University of, Orono	1	P. M. Seal
*Manhattan College, New York, N. Y.	3	J. A. Fitzgerald
*Marquette University, Milwaukee, Wis.	5	Frank Delfeld
*Maryland, University of, College Park	2	L. J. Hodgins
*Massachusetts Institute of Technology, Cambridge	1	
*Massachusetts, University of, Amherst	1	
*Michigan College of Mining and Technology, Houghton	5	G. W. Swenson
*Michigan State College, East Lansing	5	H. G. Hedges
*Michigan, University of, Ann Arbor	5	J. G. Tarboux
Milwaukee School of Engineering, Milwaukee, Wis.	5	R. J. Ungrodt
*Minnesota, University of, Minneapolis	5	P. A. Cartwright
Mississipi State College, State College	4	J. C. McKee, Jr.
*Missouri School of Mines and Metallurgy, Rolla	7	C. J. Grimm
*Missouri, University of, Columbia	7	J. C. Hogan
*Montana State College, Bozeman	9	R. F. Durnford
*Nebraska, University of, Lincoln	6	A. R. Edison
*Nevada, University of, Reno	8	W. L. Garrott
Newark College of Engineering, Newark, N. J.	3	R. E. Anderson
*New Hampshire, University of, Durham	1	J. B. Murdoch
*New Mexico College of A & M Arts, State College	7	C. D. Crosno
*New Mexico, University of, Albuquerque	7	R. A. Heaviner, Jr.
*New York, College of the City of, New York	3	W. T. Hunt
*New York University, New York, (Day)	3	S. S. L. Chang
*New York University, New York, (Evening)	3	L. J. Hollander
*North Carolina State College, Raleigh	4	E. W. Winkler
*North Dakota State College, Fargo	5	R. N. Faiman
*North Dakota, University of, Grand Forks	5	J. D. Dixon
*Northeastern University, Boston, Mass.	1	
*Northwestern University, Evanston, Ill.	5	C. W. McMullen
Norwich University, Northfield, Vt.	1	
*Notre Dame, University of, Notre Dame, Ind.	5	L. F. Stauder
Ohio Northern University, Ada, Ohio	11	J. L. Klingenberger
*Ohio State University, Columbus	11	N. A. Smith
*Ohio University, Athens	11	D. B. Green
*Oklahoma A & M College, Stillwater	7	D. L. Johnson
*Oklahoma, University of, Norman	7	C. L. Farrar
*Oregon State College, Corvallis	9	L. N. Stone
*Pennsylvania State University, University Park	2	A. P. Powell
*Pennsylvania, University of, Philadelphia	2	E. I. Hawthorne
Pittsburgh, University of, Pittsburgh	2	R. C. Gorham
*Pratt Institute, Brooklyn, N. Y.	3	Maurice Hashmall
*Princeton University, Princeton, N. J.	2	H. M. Chandler, Jr.
Puerto Rico, University of, Mayaguez	3	
*Purdue University, Lafayette, Ind.	5	Stephen Freeman, Jr.
*Rensselaer Polytechnic Institute, Troy, N. Y.	1	Emerson D. Broadwell
*Rhode Island, University of, Kingston	1	
*Rice Institute, Houston, Tex.	7	P. E. Pfeiffer
*Rose Polytechnic Institute, Terre Haute, Ind.	5	R. D. Strum
*Rutgers University, New Brunswick, N. J.	3	J. P. Newton
Saint Louis University, St. Louis, Mo.	7	W. M. McCabe
Santa Clara, University of, Santa Clara, Calif.	8	H. P. Nettesheim
*South Carolina, University of, Columbia	4	J. H. Noland, Jr.
South Dakota School of Mines and Technology, Rapid City	6	W. A. Hixson
South Dakota State College, Brookings	5	J. N. Cheadle
*Southern California, University of, Los Angeles	8	R. C. Lewis
*Southern Methodist University, Dallas, Tex.	7	F. W. Tatum
*Stanford University, Stanford, Calif.	8	W. G. Hoover
*Stevens Institute of Technology, Hoboken, N. J.	3	L. E. Backer
Swarthmore College, Swarthmore, Pa.	2	Carl Barus
*Syracuse University, Syracuse, N. Y.	1	W. R. LePage
†Tennessee Polytechnic Institute, Cookeville, Tenn.	4	
Tennessee, University of, Knoxville	4	
*Texas, A & M College of, College Station	7	N. F. Rode
†Texas College of Arts & Industries, Kingsville	7	Emerson Korges
*Texas Technological College, Lubbock	7	W. A. Blackwell
*Texas, University of, Austin, and Texas Western College Sub-Branch, El Paso	7	R. R. Krezdorn
*Toledo, University of, Toledo, Ohio	11	D. J. Ewing
*Toronto, University of, Toronto, Ont., Canada	10	J. E. Reid
*Tufts College, Medford, Mass.	1	D. E. Higginbotham
*Tulane University, New Orleans, La.	4	William Fuhr
Union College, Schenectady, N. Y.	1	O. G. Owens
United States Naval Academy, Annapolis, Md.	2	W. K. Kay
*Utah, University of, Salt Lake City	9	R. E. Stephenson
Vanderbilt University, Nashville, Tenn.	4	Walter Criley
*Vermont, University of, Burlington	1	W. L. Steinmann
*Villanova College, Villanova, Pa.	2	John B. Clothier, Jr.
Virginia Military Institute, Lexington	4	L. L. Nichols, Jr.
*Virginia Polytechnic Institute, Blacksburg	4	Claudius Lee
*Virginia University of, Charlottesville, Va.	4	C. M. Siegel
Washington, State College of, Pullman	9	R. F. Knox
*Washington, University of, Seattle	9	F. D. Robbins
*Washington University, St. Louis, Mo.	7	Olle I. Elgerd
*Wayne University, Detroit, Mich.	5	E. L. Fairchild
*West Virginia University, Morgantown	2	Everette C. Dubbe
*Wisconsin, University of, Madison	5	W. B. Swift
*Worcester Polytechnic Institute, Worcester, Mass.	1	
*Wyoming, University of, Laramie	6	R. K. Beach
*Yale University, New Haven, Conn.	1	R. R. Shank
Youngstown College, Youngstown, Ohio	2	E. A. Klingshirn

*Joint AIEE-IRE Branches . . . . 101 †Affiliate Branches . . . . 5 Total Branches 136

Policies on AIEE General and District Meetings*

Policies on All Meetings

1. *Meeting Schedules* should be planned at least 5 years in advance in order to obtain adequate hotel accommodations, and to effect planned rotation of locations. District meetings should be planned not less than 3 years in advance, in any event.

2. *Requests for Meetings* should be directed to the Institute Secretary by the District Executive Committee.

3. *Hotel Accommodations for General Meetings* should be based upon the estimated out-of-town attendance for the year in which the meeting will be held. For guidance, the total (local and visitors) registration at the Winter and Summer General Meetings for the past 10 years is shown in the table (p. 852).

4. *Payment for Hotel Meeting Rooms* should be avoided in accordance with the following policy statement (adopted by the Board of Directors, Engineers Joint Council, 11/18/54):

> The organizations endorsing this statement are educational and scientific professional associations, which are nonprofit in their operation. In serving their members these organizations find it necessary to conduct many conventions, meetings, and conferences. The primary purpose of such meetings is the exchange of technical information which will enable their professions to expand their abilities to serve all of mankind.
>
> Because of the nonprofit nature of this endeavor, it is the policy of these organizations to select facilities for such meetings where no charge is made for meeting rooms, whenever and wherever such selection is possible. Payment for such charges would handicap the other services that these organizations can render. Therefore, these organizations are opposed to the imposition of charges for rooms used for committee meetings, technical sessions, general business meetings, and conferences of members or delegates, especially when extensive use is made of other revenue-producing facilities of the meeting place. In deciding the location of conventions or conferences, preference will be given to those locations which impose no charge for rooms used for committee meetings, technical sessions, or general conferences of members.

In the event an invitation is accepted at a location at which charge for meeting rooms is made, the financing of such charges should be arranged by the local Meeting Committee, since no funds are budgeted for this purpose by the Institute.

5. *Hotel Managements* should confirm in writing all commitments (such as promised allotment of number of guest rooms, meeting rooms, committee meeting rooms, private dining rooms for committee luncheons, banquet hall, registration facilities, availability of public address systems, projector screens, and similar facilities).

NOTE: This is very *important*. Several local Meeting Committees have been seriously embarrassed in the past by finding other groups given hotel facilities promised verbally to them.

6. *Registration Fees*, in accordance with the schedule established by the Board of Directors, shall be collected by the local Meeting Committee and remitted to the Institute Secretary.

NOTE: These funds are included as "income" in the Budget and are used to offset the over-all deficit incurred in financing General and District meetings.

7. *Registration Fees for Invited Nonmember Authors* may be waived upon request of the chairman of the technical committee sponsoring the session at which the paper is to be presented at a Fall, Winter, or Summer General Meeting. At a Pacific General or District meeting, this request should be made by the local Meeting Committee.

NOTE: These requests should be directed to E. C. Day, Assistant Secretary (Papers), Committee on Technical Operations, at Headquarters, who will write to the author (copy to local Meeting Committee) advising him of waiver of the registration fee.

8. *Meeting Expenses* chargeable to the Institute are confined to those incurred in conducting the technical portion of the program, such as announcements of the meeting, badges, registration cards, projector operation, postage.

Policies on General Meetings

9. *Fall General Meeting* should be scheduled regularly in Chicago, Ill., in late September or October, with occasional selection of other midwestern locations approximately once in 5 years when specific commemorative or other occasions dictate desirability.

NOTE: (*a*). The Midwest area is defined generally as from Cleveland, Ohio, to Omaha, Nebr., and from Canada to the Gulf of Mexico (by Resolution adopted by the Board of Directors, 4/20/29).

(*b*). When held in Chicago, efforts should be made to co-ordinate the programs of the Fall General Meeting with those of the National Electronics Conference.

10. *Winter General Meeting* should be scheduled regularly in New York, N. Y., in late January or early February, with occasional selection of other eastern locations approximately once in 10 years when specific commemorative or other occasions dictate desirability.

NOTE: (*a*). Hotel reservations in New York must be made at least 5 years in advance. Consequently, invitations from other Sections must be received well in advance of 5 years.

(*b*). Meeting room accommodations should provide for 12 concurrent technical sessions and an equal number of committee meetings.

11. *Summer General Meeting* should be scheduled in various areas of United States, Canada, and Mexico in June on a planned rotation basis.

NOTE: (*a*). At present, the pattern of rotation is to hold the meeting on the Pacific Coast every 3 or 4 years; in Canada, every 5 or 6 years; and in Mexico or other location, every 10 or more years.

(*b*). Meeting-room accommodations should provide for at least five concurrent technical sessions and an equal number of committee meetings.

(*c*). This meeting should not be scheduled in any one District more frequently than every 3 years.

12. *Summer and Pacific General Meeting* (combined) should be scheduled in District 8 or 9 in June about every 3 or 4 years (recommended by Committee on Technical Operations).

NOTE: When combined with the Summer General Meeting, another Pacific General Meeting should not be held during the same calendar year.

See notes *a* and *b* under Summer General Meeting.

13. *Pacific General Meeting* should be scheduled in various locations in Districts 8 and 9 on a rotation basis planned by the District Executive Committees.

14. *Locations* for General meetings shall be approved by the Board of Directors, upon recommendation of the Committee on Planning and Co-ordination.

15. *Dates* for General meetings shall be approved by the Committee on Planning and Co-ordination acting under delegated authority by the Board of Directors.

16. *Programs for Technical Sessions* are under the jurisdiction of the Committee on Technical Operations (*Bylaw 29*).

NOTE: For the Pacific General Meeting, it has been the custom (except when combined with the Summer General Meeting) for the local Meeting Committee to arrange the technical sessions program. However, if requested, the Committee on Technical Operations will arrange the technical sessions program for the Pacific General Meeting provided the request is made at least one year in advance of the meeting.

17. *Advertising Literature* for commercial products shall not be distributed at meetings in the spaces under the control of the Institute, nor shall there by any exhibition of commercial products for the purpose of selling or taking orders for such products (*Bylaw 30*).

NOTE: Demonstration of a device or effect described in a paper presented at a technical session requires approval of the Committee on Technical Operations. This permission should be requested by the author in accordance with the outline in the "Technical Sessions Guide" (April 1954, item 8, page 4).

Policies on District Meetings

18. *Spring* (March, April, up to May 15) is the preferred period for District meetings to avoid conflict with the General meetings and peak load on Headquarters staff.

19. *Spacing* between District meetings should be at least 3 weeks.

20. *During the Year of a General Meeting* in the District, a separate District meeting should not be scheduled.

21. *Location and Dates* for District meetings shall be approved by the Committee on Planning and Co-ordination, acting under delegated authority by the Board of Directors.

22. *Papers* for District meetings may be obtained from the District membership by the District Meeting Committee, and if papers are desired from outside the District, they shall be obtained by co-operation with the Committee on Technical Operations. All papers included in the program shall be considered for publication upon the same basis as papers for General meetings (*Bylaw 35*).

*Recommended by Committee on Planning and Co-ordination, June 26, 1955. Approved by Board of Directors, June 30, 1955.

1955—AIEE Meetings Schedule—1961

Meeting	Designation	Name of Meeting	1955 Date	1955 Location	1955 Paper Closing	1956 Date	1956 Location	1956 Paper Closing	1957 Date	1957 Location	1957 Paper Closing	1958 Date	1958 Location	1958 Paper Closing	1959 Date	1959 Location	1959 Paper Closing	1960 Date	1960 Location	1960 Paper Closing	1961 Date	1961 Location	1961 Paper Closing	Future Date	Future Location	Future Paper Closing
General	WG	Winter	Jan. 31–Feb. 4	New York, N. Y.	Closed	Jan. 30–Feb. 3	New York, N. Y.	Oct. 20, 1955	Jan. 21–25	New York, N. Y.	Oct. 21, 1956	Jan. 20–24	New York, N. Y.	Oct. 20, 1957	Jan. 19–24	New York, N. Y.	Oct. 17, 1958	Feb. 1–5	New York, N. Y.	Oct. 20, 1959						
General	SG	Summer	June 27–July 1	Swampscott, Mass.	Closed	June 25–29	San Francisco, Calif.	Mar. 27, 1956	June 24–28	Montreal, Quebec	Mar. 27, 1957	June 23–27	Buffalo, N. Y.	Mar. 21, 1958	June 22–26	Seattle, Wash.	Mar. 20, 1959	June 20–24	Atlantic City, N. J.	Mar. 18, 1960	June 19–23	Ithaca, N. Y.	Mar. 17, 1961		Invited Toronto, 1963 or 1964	
General	PG	Pacific	Aug. 15–18	Butte, Mont.	Closed				Aug. 28–30	Yakima, Wash.	May 28, 1957	Aug. 19–22	Sacramento, Calif.	May 19, 1958												
General	FG	Fall	Oct. 3–7	Chicago, Ill.	Closed	Oct. 1–5	Chicago, Ill.	June 4, 1956	Oct. 7–11	Chicago, Ill.	June 7, 1957	Oct. 27–31	Pittsburgh, Pa.	June 27, 1958	Oct. 12–16	Chicago, Ill.	June 12, 1959	Oct. 10–14,	Chicago, Ill.	June 10, 1960						
District	D1	North Eastern				May 2–4	Rochester, N. Y.	Feb. 1, 1956	May 1–3	Pittsfield, Mass.	Feb. 1, 1957															
District	D2	Middle Eastern	May 4–6	Columbus, Ohio	Closed				May 7–9	Dayton, Ohio	Feb. 7, 1957															
District	D4	Southern	Apr. 13–15	St. Petersburg, Fla.	Closed				Apr. 3–5	Jackson, Miss.	Jan. 3, 1957															
District	D5	Great Lakes				Apr. 16–18	Fort Wayne, Ind.	Jan. 16, 1956	Apr. 15–17	Des Moines, Iowa	Jan. 15, 1957															
District	D7	South West				Apr. 2–4	Dallas, Tex.	Jan. 3, 1956																		
District	D11	East Central																								

Schedule of Special Technical Conferences 1955-1956

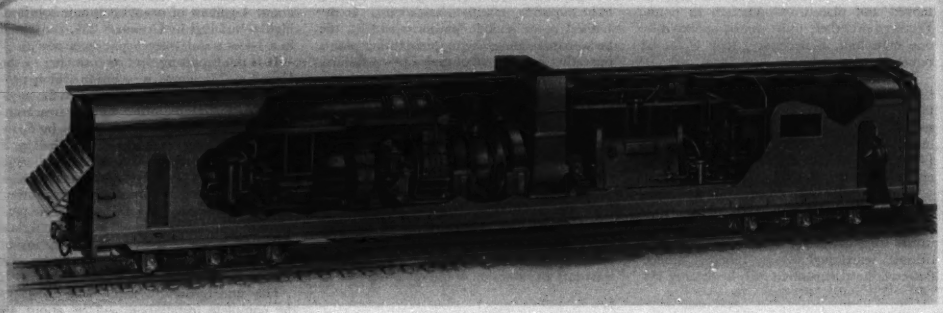
Date	Location	Name of Conference	TPS Closing Date
Sept. 12–16	Los Angeles, Calif., Shrine Auditorium	Instrument Society of America, Conference	Closed
Sept. 12–14	Houston, Tex., Shamrock Hotel	Petroleum Industry Conference	Closed
Sept. 28–29	Detroit, Mich., Rackham Memorial Audit.	AIEE-IRE Industrial Electronics Conference	Closed
Oct. 3–7	Chicago, Ill., Sherman Hotel	National Electronics Conference	Closed
Oct. 19–20	St. Louis, Mo.	Motor Applications & Problems in Heating & Cooling Conference	Closed
Oct. 25–27	Los Angeles, Calif., Hollywood Roosevelt Hotel	Aircraft Electrical Equipment Conference	Closed

Registration at Winter and Summer Meetings 1945–55

	Winter	Summer
1945	1700	1700
1946	2500	1650
1947	3700	1750
1948	3100	1550
1949	2900	1895
1950	3800	1825
1951	3300	1925
1952	3750	1850
1953	4650	2372
1954	4958	2069
1955	4650	2200

Closing dates are for Transactions papers. Approval dates refer to Directors' Meeting. T—Tentative. L—Location.

OF CURRENT INTEREST



Clark turbo-mobile power plant mounted in a specially designed railway car

Mobile Gas Turbine Power Plant Designed For Use as an Emergency Unit

THE DEVELOPMENT of a mobile power plant of unique design has been announced by Clark Brothers Company of Olean, N. Y., one of the Dresser industries. This turbo-mobile power plant is capable of developing 5500 kw. The complete plant is mounted in a single railroad car and can be placed in operation after an absolute minimum of preparation. The 5500-kw plant has as its source of power a newly designed combustion gas turbine which is directly connected to a generator.

In the picture above the opening, on the left end of the car is for air for the tube oil coolers. The opening through the roof in the center of the car is the exhaust from the turbine. Starting at the left is the diesel engine used to start the unit, the Clark gas turbine, the generator, exciter, fuel pumps, and the control room. The unit requires connection to fuel and transmission lines only.

The unit which has been built for the Bureau of Yards and Docks of the United States Navy is designed specifically as a compact, mobile source of a large amount of electric power which can be used if an emergency should occur. Even though it is an emergency unit, the power plant is of heavy duty design and can be operated continuously no matter what the duration of the emergency may be.

There were many interesting specifications involved in the design. One of these was that the entire unit had to be contained in one railroad car of such size and design that it could be moved at high speed in any freight or passenger train service without equipment damage.

It also had to be ready to operate within 24 hours after its arrival at a site. Operation on a wide range of liquid and gaseous fuels, in combination or interchangeably, was another important consideration. The only connections were to be to a fuel source and the transmission line. Water supply was not to be required. The gas-turbine-driven unit developed by Clark meets all of these specifications.

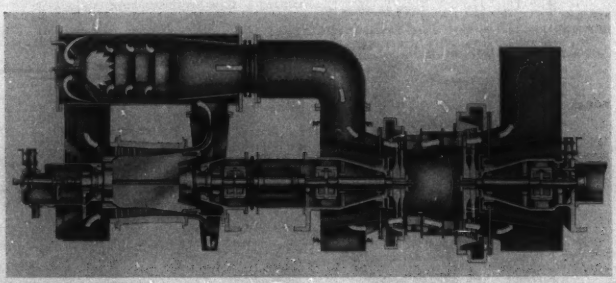
Many other types of emergencies often require the use of electric power. An example of such a situation may be found in Mexico where a Clark turbo-mobile power plant was recently sold.

The Comision Federal de Electricidad, together with the private companies in Mexico, are primarily integrated in metropolitan areas. The large distances between these cities and areas requiring power have resulted in many sizeable but relatively isolated power systems.

It is not feasible to provide stand-by or back-up capacity for each of the power systems. Similarly, it is not economical to build transmission lines in order to interconnect all of the areas in use. Mobile power has, therefore, been the best answer. Mobile steam and diesel plants have been used but they are not an entirely satisfactory answer. The ideal plant should be of a size that will be most effective. This requires 5,000 to 10,000 kw.

Portable diesel-generator sets are large and heavy with respect to their output.

A mobile steam plant such as the 10,000-kw trains built for the United States Navy during World War II has been used in Mexico. Although the rating is satisfactory, the water requirements, the number of cars involved, and the complexity of putting the



CROSS SECTION shows the flow of air and gas through the gas turbines. Air enters the axial compressor at the lower left. The 13 stage unit discharges air into the combustion chamber at the upper left where it is mixed with either liquid or gaseous fuel and burned. The hot gases enter the high-pressure turbine, center, which turns this turbine and also turns the axial compressor connected to it. Next, the hot gases enter the low-pressure turbine, right, which is connected to the load. Subsequently, the gas discharges through the roof of the car. The unit is started by a diesel which is connected to the extension shaft of the axial through a torque converter and clutch. As soon as the diesel has brought the axial up to a high enough speed to furnish sufficient air for combustion, the diesel disengages and the unit is self-sustaining.

unit in operation make it a less desirable application.

The Clark turbo-mobile power plant, however, eliminates all of these basic objections. It is satisfactory from a size viewpoint, it does not require water, and it may be moved and placed in operation in hours. Furthermore, these units can be operated by one man and, if necessary, they could be remotely operated.

The first turbo-mobile power unit has been built by Clark Brothers Company under contact to the United States Navy. A second unit rated at 6,200 kw is being manufactured for The Comision Federal de Electricidad in Mexico. It will be placed in operation next spring.

Another very important use for these turbo-mobile power plants is to meet emergencies which frequently arise from natural causes such as floods, fires, tornadoes, hurricanes, earthquakes, and many others. Power failures can often affect not only the disaster areas, but nearby areas as well. Mobile power plants, strategically located throughout such areas, could make power available quickly wherever it is needed.

In the event of hostilities, turbo-mobile power plants of this type would be well suited to be moved in on ships to base areas. In the United States mobile power would be the answer to keeping key manufacturing plants operating in the event of major power failure. The essential facilities of large cities, such as water pumps, hospitals, etc., could also be kept operating.

An emergency of a less ghastly though highly important nature, is to meet the power requirements of fast expanding areas. The trend toward decentralization in our rapidly growing communities can result in a distribution problem, particularly in new areas which are beyond the major power distribution system. The mobile unit will provide immediate power until the load growth warrants an extension of the major system.

First Atomic Energy Reactor Designed for Research at UCLA

THE FIRST ATOMIC energy reactor specifically designed for medical treatment and research will be built for the University of California in a new underground wing at Los Angeles Medical Center by North American Aviation's Nuclear Engineering and Manufacturing Division.

The new reactor will produce gamma rays and neutrons for cancer therapy, and also has been designed to serve a variety of additional medical and nonmedical uses, including the production of radioisotopes and radiations for experimental sterilization and preservation of food and drugs by nuclear energy. The reactor, which is expected to be completed within one year, also will be available for use by the Atomic Energy Commission (AEC) in conjunction with the Atomic Energy Project at the University of California, where both classified and unclassified research in biology and medicine is carried on.

Designed to operate at a power level of 5 kw with a maximum power of 50 kw, the medical reactor will produce a high intensity of neutrons, subatomic particles available only from a nuclear reactor in the large amounts required for medical therapy and other atomic research. Gamma rays produced by the reactor will be of greater intensity than those produced by 50 pounds of radium.

The reactor's atomic fuel is to be obtained on loan from the AEC, and will consist of about 4 gallons of uranyl sulphate solution, highly enriched in Uranium 235, contained in a 1-foot stainless-steel sphere, or core.

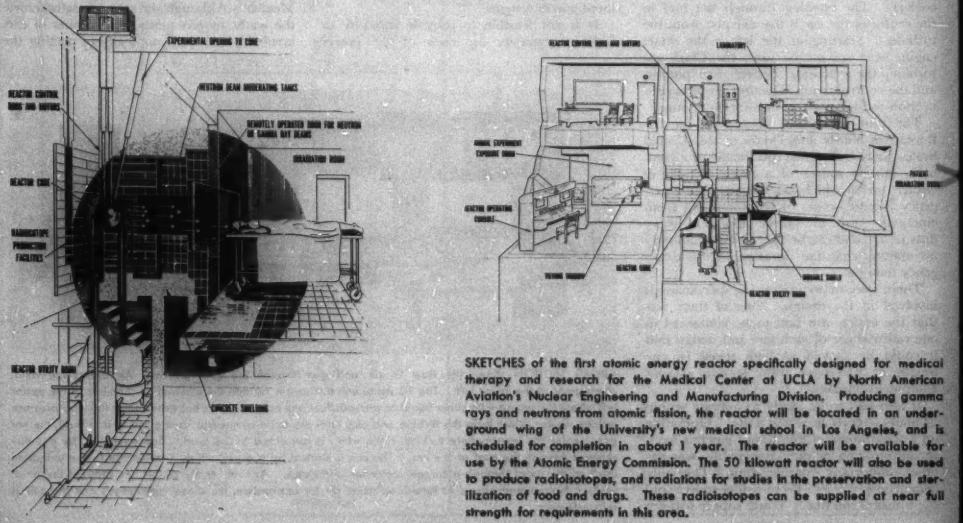
It is the "splitting up" or fissioning of the Uranium 235 atoms in solution which provides the gamma rays and neutrons for medical treatment and other nuclear research. The core will be located inside a 5- by 5- by 8-foot stack of graphite bars, shielded by 5 feet of high-density concrete. Radiation ports will lead from the core to a patient treatment room, laboratory, and another room where research on animals can be performed. An access port will permit materials to be irradiated in a channel leading inside the core itself where radiation will be the strongest.

The underground reactor wing housing the complete installation will be about 45 feet wide, 60 feet long, and 27 feet high.

Rate of fission will be adjusted by control rods made of boron which can be moved in and out of the core area. Boron absorbs neutrons, thus, when the rods are near the core neutrons are "soaked up." As the Uranium 235 atoms are split when hit by neutrons, fission will stop when the neutrons are caught by the boron rods.

The solution type reactor will be self-contained, with no radioactive particles, fumes, or smoke being exhausted into the atmosphere or public disposal systems.

Either gamma rays or neutrons can be obtained from the reactor for cancer treatment. While both are radiated from the reactor during the fission process, gamma rays or neutrons can be selected by use of special shielding equipment between the patient's room and the reactor core. The size of radiation ports can also be varied to provide radiation in the required amounts or intensities.



SKETCHES of the first atomic energy reactor specifically designed for medical therapy and research for the Medical Center at UCLA by North American Aviation's Nuclear Engineering and Manufacturing Division. Producing gamma rays and neutrons from atomic fission, the reactor will be located in an underground wing of the University's new medical school in Los Angeles, and is scheduled for completion in about 1 year. The reactor will be available for use by the Atomic Energy Commission. The 50 kilowatt reactor will also be used to produce radioisotopes, and radiations for studies in the preservation and sterilization of food and drugs. These radioisotopes can be supplied at near full strength for requirements in this area.

Gamma rays destroy cancer cells much in the same way as is done by X rays, but the gamma rays penetrate deeper through tissue and are much stronger than X rays.

Irradiation of cancer cells with neutrons is often accomplished by the boron capture technique. This method requires the injection into a tumor of a solution containing the element boron. Due to the particular nature of the cancer cell, the cancerous tissue absorbs the boron much more quickly and in greater amounts than does healthy tissue. When the cancer area is bombarded by a stream of neutrons, the boron atoms in the cancer cells release alpha particles. These particles, which are tiny masses carrying an electric charge and weigh about four times as much as a neutron, are effective cancer cell killers. Alpha particles have a short penetration range, primarily confining their destruction to cancer cells and doing relatively little harm to healthy tissue.

Although radioisotopes are available from reactors located in various parts of the United States, the strength of the radioactivity of these materials is often dissipated by the time they have traveled long distances. The University of California reactor could provide these materials at near full strength for requirements in the area.

New Processing Center for Electronic Data Opened by IBM

International Business Machines Corporation (IBM) recently demonstrated its new electronic data-processing center on the main floor of the company's headquarters.

The center contains an integrated team of so-called "giant brains," a complete lineup of high-speed digital computers and data processing equipment. Included are the IBM *702*, *701*, and *650* electronic data-processing machines as well as smaller, medium-sized electronic calculators.

This versatile combination of machines makes available on an hourly charge basis the latest tools for scientific management to companies which do not need full-time data-processing facilities of such capacity and speed, and to companies whose own facilities are overloaded.

An outstanding feature was a series of demonstrations on the three largest machines. The *702* processed a day's activities on a 2,500-item inventory in 8 minutes. The *650* calculated part of a 2,400-employee factory payroll, which in its entirety would take only 3 hours to complete, paychecks and department cost accounting included. And the *701*, running a mere 10 minutes, solved a complex transportation problem to minimize costs for a company desiring to ship various quantities of a product from four origins to 51 destinations.

The center can handle all types of data-processing work. For example, for major business applications there is the *702*, the latest heavy-duty machine to be developed. The basic hourly charge for the *702* in the center is $445.

Associated with the *702* is the latest high-speed printer, which prints results calculated by the giant machine at the rate of 1,000 lines a minute. At this rate it could record the equivalent of a 400-page novel in about 4 minutes. For large-scale scientific and engineering calculations there is the *702*'s technically minded running mate—the *701*. It has been available on an hourly charge basis at headquarters in New York for over 2 years and, operating around the clock, has handled a variety of complex assignments for business, industry, and government. The predecessor to the *701* was the Selective Sequence Electronic Calculator (SSEC), installed at the site of the new center in 1948. The SSEC was the first large commercial machine made available to industry.

For either business or scientific work on a smaller scale, the center has a *650* magnetic-drum machine. The *650*, a card-input, card-output machine, will now also be available as a tape-operated machine with a printer output.

Also in the processing center are smaller

IBM 702 is shown at the new Data Processing Center at New York City headquarters. The equipment shown above (left to right): arithmetical and logical unit, eight magnetic tape units and power supply, console (foreground), card punch, printer, and card reader. Several units of the 702 are not shown, such as the magnetic drum memory, auxiliary tape units, and control and electrostatic storage facilities.

Future Meetings of Other Societies

Machine Tool Show; Production Engineering Show (held concurrently). September 6–17, 1955, International Amphitheatre and Navy Pier, Chicago, Ill.

Instrument Society of America, Conference, "Instrumentation Paces Automation." September 12–16, 1955, Shrine Auditorium, Los Angeles, Calif.

Illuminating Engineering Society, National Technical Conference. September 12–16, 1955, Statler Hotel, Cleveland, Ohio

Association for Computing Machinery, Annual Meeting. September 14–16, 1955, University of Pennsylvania, Philadelphia, Pa.

Institute of Radio Engineers, Second National Annual Meeting of Professional Group on Nuclear Science. September 14–16, 1955, Oak Ridge, Tenn.

Radio-Electronics-Television Manufacturers Association, Automation Symposium. September 26–27, 1955, Irvine Auditorium, University of Pennsylvania, Philadelphia, Pa. Radio Fall Meeting. October 17–19, 1955, Hotel Syracuse, Syracuse, N. Y.

Atomic Industrial Forum, Trade Fair and Fall Meeting. September 26–30, 1955, Sheraton-Park Hotel, Washington, D.C.

Société Belge des Ingenieurs des Telecommunication et d'Electronique, International Analogy Computation Meeting. September 27–October 1, 1955, Brussels, Belgium

Standards Engineers Society, Fourth Annual Meeting. September 29–October 1, 1955, Hote Statler, Hartford, Conn.

National Electronics Conference, Inc. October 3–5, 1955, Hotel Sherman, Chicago, Ill.

Canadian Electrical Manufacturers Association, 11th Annual Meeting. October 5–7, 1955, Sheraton-Brock Hotel, Niagara Falls, Ont., Canada

Electrochemical Society, Inc. October 9–13, 1955, William Penn Hotel, Pittsburgh, Pa.

Eastern Electrical Wholesalers Association, Third National Electrical Industries Show. October 11–14, 1955, 69th Regiment Armory, New York, N. Y.

National Safety Council, 43d National Safety Congress and Exposition. October 17–21, 1955, Conrad Hilton, Congress, Morrison, and La-Salle Hotels, Chicago, Ill.

Steel Founders' Society of America, Fall Meeting. October 24–25, 1955, The Greenbrier, White Sulphur Springs, W. Va.

American Standards Association, 37th Annual Meeting in conjunction with 6th National Conference on Standards sponsored jointly by ASA and the National Bureau of Standards. October 24–26, 1955, Sheraton-Park Hotel, Washington, D.C.

Pennsylvania Electric Association, Fall Meeting of Electrical Equipment Committee. October 27–28, 1955, Hotel New Yorker, N.Y.C.

National Conference on Industrial Hydraulics, 11th Annual Meeting, October 27–28, La Salle Hotel, Chicago, Ill.

Institute of Radio Engineers, East Coast Conference on Aeronautical and Navigational Electronics, October 31–November 1, Lord Baltimore Hotel, Baltimore, Md.

accounting machines, such as the *604* Electronic Calculator costing $15 an hour and other punch card equipment. One of these machines is the Data Transceiver which permits companies to make rapid use of the center's processing facilities from remote points. Westinghouse Electric Corporation, in Pittsburgh, Pa., is using the center's *701* via Transceiver to solve engineering design and development problems.

The New York installation is the first of several to be opened at IBM offices in major cities. The purpose of these centers is to make electronic data processing available to more companies and institutions, particularly those which need only limited use of the biggest and fastest machines.

Another highlight of the demonstration was the showing of the new sound-color motion picture, "Direct Line To Decision." The 22-minute film deals with the problems encountered by management in processing the mountain of paperwork confronting office forces today, and traces the development of the company's high-speed data-processing machines.

Power From Prototype Reactor Produced for Niagara Mohawk

THE ATOMIC POWER PLANT which will power the Navy submarine Seawolf has a sister power plant which on July 18th supplied energy for the production and sale of the United States' first atomic electricity for farms, homes, and industries.

The Submarine Intermediate Reactor (SIR) Mark *B*, designed and constructed by the General Electric Company for the Atomic Energy Commission, will power the Seawolf.

The sister power plant, the SIR Mark *A*, a land-based prototype, also constructed by the General Electric Company, is located inside the world's largest steel sphere of its kind at West Milton, N. Y., where it is undergoing tests.

Steam from this power plant was piped into a G-E turbine-generator, just outside the sphere. The generator began producing electricity for use in northeastern New York, which is being transmitted over the facilities of the Niagara Mohawk Power Corporation.

The 10,000-kw turbine-generator was installed and is being operated by the General Electric Company at no expense to the government.

Generating its normal output of 10,000 kw continuously, the West Milton power plant could produce enough power to supply the electrical needs of a city of 30,000 people.

Inside the 225-foot steel sphere, the prototype nuclear reactor produces heat that is carried to a heat exchanger by means of liquid sodium metal. In the heat exchanger water is converted to steam to drive turbines.

At West Milton, a part of this excess steam is being used to produce peacetime electric power. The turbine-generator will continue to produce this power for about the next $2^1/_2$ years.

The Seawolf reactor will incorporate the same principles that are being tested at the West Milton site. It will be the first submarine reactor to use neutrons in the "intermediate" range and to employ liquid sodium metal as a coolant.

MIT Computer Analyzes Brain Waves

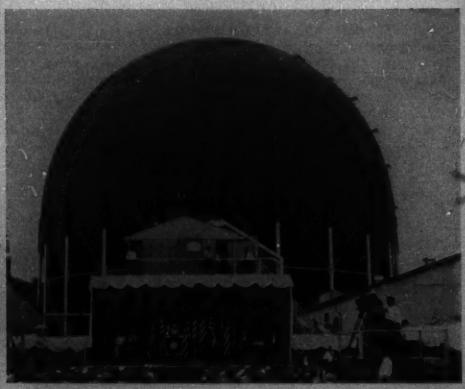
A new electronic computer for analyzing the rapid and complex electrical activity of the brain is in preliminary tests at the Massachusetts Institute of Technology (MIT), Cambridge, and the Massachusetts General Hospital.

This instrument displays, in a new and rather different form, the information in these tiny electric impulses that are related to the nervous system's operating and controlling mechanism. By automatically comparing brain waves in one short time period with those which preceded them, the computer shows a time sequence of brain wave activity.

This computer makes it easier to answer such questions as: "How stable a phenomenon are brain waves? Are there wave patterns which repeat periodically? If a range of normal stability for brain waves can be defined, can we then determine variations from this norm in children; in older people; in those with mental disease?"

In an invited lecture at the University of Southampton, England, Dr. Norbert Wiener, professor of mathematics at MIT, described the use of this new equipment to show the rhythms of the well-known brain waves which have long been familiar to medical research. The new form of presentation now permits us to describe these as Dr. Wiener said, "an accurate clock in the brain of man—a clock of good consistency, beating about 10 times per second, and keeping phase with itself for perhaps hundreds of seconds."

"Clocking is both a useful and recognized phenomenon in many mechanical control machines," Dr. Wiener continued, "and it seems likely to be equally essential in the control machine of the brain. Here we think



SUBMARINE HULL SECTION (left) and water tank surrounding reactor section of hull are shown inside huge steel sphere at West Milton, N. Y., where prototype reactor for Navy submarine Seawolf is being tested. Steam from prototype reactor is being used to produce atomic electricity available for use in homes and industries at plant installed by the General Electric Company. The atomic plant for the Seawolf is being constructed for the Atomic Energy Commission.

Dedication of facilities (right) for generation of free world's first commercial atomic electric power was held at nearby West Milton, N. Y. in front of huge sphere housing prototype atomic power plant for Navy Submarine Seawolf. Speaking is Ralph J. Cordiner, president of General Electric Company. Meter above speaker's stand indicated first power being produced by G-E turbine-generator, powered by steam from submarine prototype reactor. Reactor was constructed for the Atomic Energy Commission. Power was transmitted to homes, farms, and industries in upstate New York over lines of Niagara Mohawk Power Corporation.

it may have something to do with the human's intelligence and organized functioning."

The clock-like signals are found combined with a great number of tiny random pulses. The contribution of the new machine is to sort automatically this random activity in order to get at such consistent signals as Dr. Wiener described.

In some individuals, Dr. Wiener said, these minute but precise electric signals following one after another "stand out with the utmost clarity and persistence, continuing at about a constant level for what we know to be as much as 15 seconds." In other cases, this signal is not so clear or persistent; for the present there seems no way to know the basis of these differences.

The preliminary results which Dr. Wiener described came from equipment developed in the Research Laboratory of Electronics (RLE) at MIT in conjunction with a research group at the Massachusetts General Hospital. Dr. John S. Barlow of the Massachusetts General Hospital and Robert M. Brown of MIT's Research Laboratory of Electronics began work in 1952 on this analogue correlator, a type of very specialized computing machine. The machine has been in use for several months in tests conducted under the direction of Dr. Mary A. B. Brazier, neurophysiologist to the Neurological Service at the Massachusetts General Hospital, and Dr. Walter A. Rosenblith, associate professor of communications biophysics at MIT, both important contributors to the machine's development. In addition to their Massachusetts General Hospital appointments, Dr. Barlow and Dr. Brazier are RLE staff members and research associates in electrical engineering at MIT.

Dr. Wiener, whose early work in mathematical analysis and correlation laid the foundation for the developments now being reported, is also participating actively in the current work.

Dr. Brazier points out that the electrical activity of the brain, which has for many years been her field of special interest, is extraordinarily complex. Systematic analysis of this activity has been heretofore impossible except when conductd on a relatively limited scale.

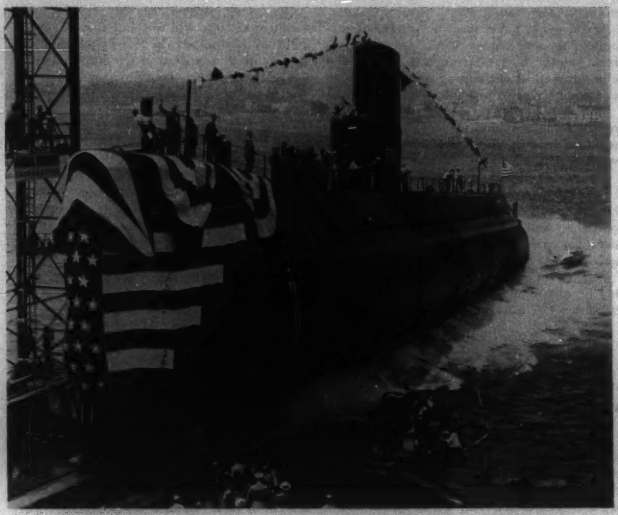
"All nervous activity is accompanied by electric signals," said Dr. Brazier, "Since the first discovery of these brain waves, scientists have focussed their attention on efforts to sort out various components of this pattern and to understand the relationships between them. As a result, for years we have known that brain waves contain elements important in diagnosing disease and in learning more of the fundamental processes of human thought and action. But our tools have been inadequate to answer many of the most important questions."

The current work at MIT is an outgrowth of the first use of correlation techniques on brain waves at the Massachusetts General Hospital in 1949. In the work Dr. Brazier was associated with James U. Casby.

"Our present analogue correlator," Professor Rosenblith said, "takes brain waves as recorded on tape, processes them, and, in an operation almost entirely automatic, prints a graph that indicates the continuity of the patterns over the time intervals we may choose. The development of this specialized equipment, is not only a tribute to Dr. Wiener's ideas; it is also a very practical illustration of the way in which medicine, the biological sciences, mathematics, and electrical engineering combine forces to attack age-old problems."

Members of this MIT–Massachusetts General Hospital group emphasize that work is just beginning, only a few records have thus far been analyzed, and no final conclusions are justified.

Seawolf, Second Atomic Sub Launched



SECOND ATOMIC SUBMARINE, Seawolf (SSN575), was launched at the Electric Boat Division of General Dynamics Corporation, Groton, Conn., on July 21, 1955. The atomic power plant of the Seawolf will be of a different design from that of the Nautilus whose power plant, called the submarine thermal reactor, is cooled by high-pressure water. Another type of reactor, the submarine intermediate reactor, will be installed in this newest underwater craft. This one is cooled by liquid sodium. The speed of the 330-foot submarine will be more than 20 knots. In addition to the sodium-cooled reactor, the Seawolf will have auxiliary propulsion of storage battery and diesel-electric drive.

JETS Bring Engineering Facts to High Schools in 11 States

Junior Engineering Training for Schools (JETS), an organization dedicated to bringing the facts about engineering to high schools in a way that helps students and hard-pressed schools of engineering, this Fall enters its fifth year of activity. Since the first club was organized in the East Lansing, Mich., High School in November 1950, the program has spread to include 59 clubs in 11 states with an active membership of more than 1,000 boys and girls.

The working idea for JETS originated in 1950 with L. G. Miller, then dean of engineering at Michigan State University (MSU). He believed there should be a "4-H Club of Engineering" to tell young men and women what engineering is and what opportunities it offers.

"We agreed that the word about engineering was just not getting through to the majority of students in high school who are are interested in engineering," said Michigan's Professor H. P. Skamser, director of the JETS program. He pointed out that although there are counselors, books, and bulletins with information about engineering, few potential engineers go to these sources for information. In the JETS program they can learn the real nature of engineering and compare their talents and abilities with the requirements of the profession.

Club members receive first-hand information through individual and club projects, talks with professional engineers and members of the University staff, and through engineering films and publications.

New clubs receive kits listing interesting engineering projects, and a cross-indexed listing of more than 100 motion pictures about all phases of engineering, available from industry and other sources without charge. A club newsletter, *Jets-O-Gram*, is circulated to all clubs.

MSU is active in judging club projects and presenting a scholarship program. The projects of club members compete each year for honors at the MSU Engineering Exposition. The scholarship program, offered to the outstanding student in each club, covers 4 years' tuition at MSU.

JETS club officials point out that the program is proving effective not only in stimulating interest about engineering but also in another important way: steering some students, who have misconceptions about engineering and whose talents are in other areas, away from engineering. Officials believe this effect of the program tends to reduce engineering "drop-outs."

Success of the program has brought appeals for information about the clubs from industrial leaders and educators from all over the United States. That the program is getting results in the clubs is evident in reactions from both teachers and students. Officials believe the program's realistic approach and enthusiastic response are making a real contribution to engineering in the United States.

Detailed information about the program may be obtained by writing to JETS, Post Office Box 470, East Lansing, Mich.

Army Power Reactor Will Be Transportable by Air

Engineering work is well underway on the new Army Package Power Reactor (APPR) project for installation at the Army's Engineering Research and Development Laboratory at Fort Belvoir, Va., where initial construction will start later this year. Operation of the project is scheduled for 1957. This small power plant will employ components which can be transported by air to remote bases in any part of the world. A small charge of fuel will operate the plant at its full capacity for a period of 18 months.

Alco Products, Inc. employed Stone and Webster as its consultant on the preliminary design, estimate, and proposal of the new nuclear power "package," receiving its own contract last December. This is Stone and Webster's second nuclear power project, having been selected by Westinghouse Electric Corporation as architect-engineers for the Pressurized Water Reactor to be operated by Duquesne Light Company at Shippingport, Pa.

The Fort Belvoir nuclear reactor and steam generator will be housed in a vapor-tight steel container 36 feet in diameter by 64 feet high, as shown in the accompanying perspective. This container will be installed to prevent the escape of fission products.

Heat from the reactor will be turned into steam in a steam generator. This steam will flow to a 2,000-kw turbine generator located in an adjacent powerhouse. Circulating water for the condenser will be taken from the Potomac river. Electricity generated in this power house will be utilized at the Fort Belvoir installation.

Alco Products, Inc. will supply the larger components, including reactor, steam generator, heat exchangers, and main condenser. Other components, such as the turbine generator and pumps, will be purchased from leading manufacturers on a competitive bidding basis. Alco Products, through its nuclear engineering department, will also provide the basic design for the reactor, its shielding, waste disposal, and safety provisions.

It is expected that the Fort Belvoir plant will provide experience leading to the design of many portable nuclear power plants which may be set up in locations remote from sources of fuel. Such a development is not only significant from a military logistics viewpoint, but it will also permit new areas to be developed for many peacetime uses such as mining, meteorological observation, airports, and remote supply bases.

Image Amplifier Tube Uses Gas Which Traps Electrons

The image amplifier tube employs perfluoro-cyclic ether, one of the newest insulating materials in use in the electrical industry. This gas insulator, adapted by the Westinghouse Electric Corporation's X-Ray Division in Baltimore, is composed of carbon, fluorine, and oxygen. The gas is used inside the tube where the electric connections are made.

The image amplifier tube is basically a light amplifier tube. It takes very dim fluoroscopic images at one end of the tube and transforms them into bright light images (200 to 400 times) at the other end. Therefore, any bright light outside the tube formed by corona would shine inside the tube and also be brightened. This would blot out the fluoroscopic image which the physician is trying to observe.

By excluding the air from within the housing and replacing it with a suitable insulating gas, no visible corona is formed until voltages considerably above 30,000 are reached. A much larger housing, filling the air space with oil, making large rounded smooth connections are other methods used to prevent corona. However, these methods are impractical, because both weight and size of the unit would have to be increased significantly.

The gas is introduced into the housing in a simple manner. First, most of the air is replaced by nitrogen gas. This is done by flushing the nitrogen through the housing. Then two cubic centimeters of liquid perfluoro-cyclic ether are injected into the housing, through a rubber disk, by means of a hypodermic needle. This liquid evaporates in the nitrogen, and the resulting gas mixture has about $2^1/_2$ times the electrical strength of air.

Perfluoro-cyclic ether is an electronegative material; therefore, it tries to capture any free electrons moving about in the gas. Since corona is formed by the movement of free electrons and ions, higher voltages are necessary to form corona in this gas.

New Silicon Power Rectifier Announced by Bell Laboratories

A tiny new power rectifier made of extremely pure silicon shows promise of reducing costs on a large scale in many industries using electric power, Bell Telephone Laboratories has announced.

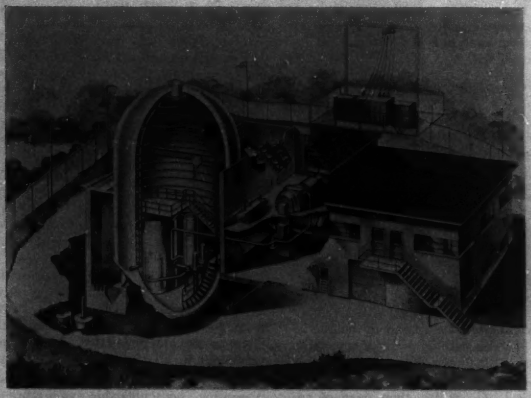
Despite a trend in recent years toward smaller and more efficient components, power rectifiers have remained large, limited in efficiency, and in need of bulky cooling equipment to prevent overheating.

Bell scientists believe that the new power rectifier will far surpass any yet made of silicon or other material. They expect it may have an almost unlimited life span, and will be capable of operating continuously at temperatures up to 400 F.

These advantages are expected to open up many new uses in telecommunication, heavy industry, and military applications. The rectifier's efficiency—more than 98 per cent of the theoretical limit—was made possible by recent work of M. B. Prince, a Bell Laboratories physicist.

Two of the new rectifiers, when made about the size of peas, linked together and mounted on a cooling fin will furnish more than 20 amperes of direct current at 100 volts. This amounts to 2,000 watts—with only 20 watts lost through heat.

Only 1 ampere or less is needed to operate a radio or television set or a group of telephone switching relays. To charge storage



NEW US Army Package Power Reactor is shown in perspective drawings. Component parts will be transportable by air anywhere in the world. As the initial "package" power plant, it will be constructed at the Army's Engineering Research and Development Laboratory at Fort Belvoir, Va. With engineering work well underway, initial construction is expected in September.

batteries used in automobiles and telephone central offices or to operate electric motors, from 10 to more than 100 amperes may be needed.

Highly purified silicon is a costly material when bought in pound quantities, but such minute amounts are used in the new rectifier that the material becomes relatively inexpensive to use. A rectifier the size of a pea, for example, contains a silicon wafer only 0.005 inch thick and 0.1 inch square.

Even smaller rectifiers have been made and will be desirable for use in the telephone system and in electronic computers.

Larger rectifiers are necessary for other uses where greater amounts of power must be handled. The size of the wafer would vary, just as the size of a copper wire ranges from thin to heavy depending upon the current that must be carried.

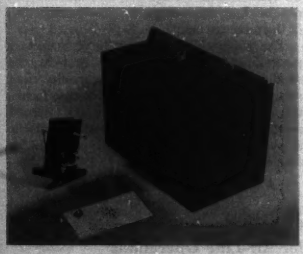
The new silicon rectifiers provide 5,000 times more current than conventional rectifiers of the same size, thus permitting miniature operating units. Even so, the newest techniques may be applied to large sizes and thereby provide entirely new current and power possibilities for industry. On a machine the size of a locomotive, for example, significant amounts of space may be saved by the new rectifiers.

The silicon power rectifier grew out of the same broad research program at Bell Laboratories which produced the transistor a tiny, long-lived amplifying device, and the solar battery, the first device to convert sunlight into substantial amounts of electricity.

The techniques created at the Laboratories for producing this silicon device involve the controlled introduction of impurity elements into the layers near the surface of a thin slice of silicon. Treatment with vapors at high temperatures causes minute traces of impurities to enter the crystalline structure of the silicon. Before this process begins the silicon must first be so pure that there is less than one impurity atom per billion silicon atoms.

The controlled introduction of impurity atoms forms in the silicon a *p-n* junction, which is the heart of the transistor. C. S. Fuller and G. L. Pearson, of Bell Telephone Laboratories, announced the application of the techniques to power rectifiers more than a year ago.

Production plans for the new silicon power rectifier are being worked out with the Western Electric Company, manufacturing unit of the Bell System. Production will start soon for both the Bell System and military use.



SELENIUM POWER RECTIFIER (right) used in the telephone system for converting alternating to direct current. At left is Bell Telephone Laboratories' new silicon power rectifying units, which may replace selenium units. Active elements are 4 wafers 1/10 inch square, such as those on the paper in the foreground, which do the rectifying work of the 20 selenium-coated fins on the big rectifier. The 20 fins are also used for cooling. In the silicon rectifier at left, cooling is done by two small fins. A wafer is placed in a tiny can, which in turn is attached to a bolt for mounting, as shown in the left foreground with the wafers. In a silicon rectifying unit two elements are attached to each fin.

Navy's Newest Guided Missile

A CONVAIR TERRIER, the Navy's newest antiaircraft guided missile, takes off from the deck of the converted battleship USS Mississippi on its mission of knocking down an attacking "enemy" aircraft. Capable of supersonic speeds, the rocket-propelled Terrier can find and destroy its target under any conditions of visibility or weather. Far deadlier than even the largest antiaircraft guns, it will be the primary armament on the Navy's first two guided missile cruisers, the USS Boston and USS Canberra. The Marine Corps also has adopted the Terrier as its first antiaircraft missile for use in amphibious operations. The Terrier was developed for the Navy Bureau of Ordnance by Convair Division of General Dynamics Corporation under the technical direction of Johns Hopkins University Applied Physics Laboratory. The new missile is being produced in quantity by Convair at its Pomona, Calif., plant.

Annual Report Shows West German Advances

During 1954 the West German electric equipment industry placed increased emphasis on research in the fields of communications and measuring apparatus. Indicative of this trend was the fact that a new communications engineering association was founded, a new laboratory was erected for the development of these types of equipment, and improved types of instrumentation were developed.

Reliable industrial sources also noted a strong trend toward research in developing and applying diverse new materials, particularly in the regulation and control equipment sector. For example, the firm Dr. Beck and Company, Hamburg, Western Germany's only factory specializing in the production of insulating varnish and artificial resins for use in electric equipment, developed new plastic coatings which it claims are equal to or better than similar American products.

With the achievement of sovereignty by Western Germany on May 5, 1955, the field of research in the electric equipment industry was expanded to include radar, Geiger counters, and similar nuclear research apparatus.

Important Technological Advances

The Allgemeine Elektrizitaetsgesellschaft (AEG), Frankfort/Main, has developed a simple new electrostatic sprayer designed for mass production coating of metallic surfaces ranging in size from toys to automobile bodies. The manufacturer claims the machine is safe, economical, and simple to use.

In operation, a spraying fluid is pumped from a tank onto a spray pan carrying a 100-kv charge, while the work-piece on the conveyor is grounded. Thus, when the work-piece approaches the sprayer, droplets of the fluid are attracted to the work-piece and distribute themselves evenly over the surface. If desired, the direction and density of the spray can be controlled by means of deflector electrodes. Remote-control operation permits the use of toxic spraying compounds.

The Radium Elektrizitaetsgesellschaft, Wipperfuerth, has developed for commercial use a high-pressure mercury-vapor lamp, coated with fluorescent material, which emits a "golden-white" light instead of the usual bluish shade. Besides the usual features of economy in operation and long service life, the manufacturer claims that the new bulb is designed so that temperature and intensity of light are distributed evenly over its surface. Like all standard mercury vapor lamps, these bulbs require a special auxiliary. They come in six sizes ranging from 75 to 1,000 watts. A reflector model is available in 250- and 400-watt sizes.

For registering short circuits and power failures in distributing lines and relays, Siemens and Halske has developed a series of three new combination indicating and recording meters. Each unit is equipped with three or four indicating meters and six to ten styluses which record on a metal strip chart. The normal recording speed of 20 mm per hour is automatically stepped up to 20 mm per second when a power failure or short circuit occurs.

The firm Hans Heidolph, Schwabach, Bavaria, has put on the market a new series of miniature gear motors. The single-phase squirrel-cage motor is equipped with starting coils and operates on 10 to 50 watts. This motor is coupled to infinitely variable gears which vary the speed of the motor output shaft from 0 to 2,500 rpm, while the motor operates at full speed. By adding a reduction gear, two speed ranges are obtainable.

The Electroacustic GmbH, Kiel, has put on the market a new stationary spindle for phonograph record changers which, it claims, reduces hole wear and eliminates the need for record balast arms. The spindle is of the straight type and holds ten 78- or $33^1/_3$-rpm records. In operation, a stack of records rests on a record shelf composed of three retractable retainers. When the records are being changed, three spring-action prongs located one record-thickness above the record shelf expand to hold the stack while the retainers retract to permit the lowest record to drop to the turntable. The cycle is then reversed. The prongs retract, lowering the stack to the record shelf, until the next record change occurs. For single-play action the spindle is inverted.

New Munich Research Center Opened

At the end of December 1954, Siemens and Halske opened a new communications research laboratory in Munich. Described as one of the largest establishments of its type in Western Germany, the building is nine stories high, has 11,000 square meters of working space and will accommodate a staff of 1,200. According to a company spokesman, 58 per cent of all research financed by Siemens and Halske will be concentrated in this new plant. This is the fourth laboratory operated by Siemens and Halske, the others being located in Berlin, Karlsruhe, and Brunswick.

New Research Society

On April 6, 1954, the Association of the German Electrical Engineers (VDE), Frankfort/Main, founded a new subdivision entitled the Society of Communications Engineers (Nachrichtentechnische Gesellschaft, NTG). Established as a nation-wide non-profit organization with headquarters in Darmstadt, the society has a total of 1,000 members at present. The society is subdivided into 20 sections covering all fields of communications engineering.

Tiny Elgin Cell Delivers Constant Voltage for 2 Years

For many years the research department of Elgin National Watch Company has been processing an electric battery suitable for use in fine instruments, particularly for use in electronic watches currently under development by the company. In the course of this research, it has become apparent that the cell may be applicable to that large variety of commercial devices requiring batteries which offer ultimate dependability and long service life. The achievement of these characteristics in the Elgin indium cell makes it an ideal replacement for the mercury cells presently in commercial use. However, it differs from the mercury cells in many important respects:

1. The most serious commercial disadvantage of mercury cells has been overcome in the new system—that of parasitic reactions occurring during storage and discharge. These side reactions result in the formation of gaseous products which may often cause battery swelling and electrolyte leakage. In precision equipment where batteries are in close proximity to expensive components, electrolyte leakage can be costly due to its corrosive nature. Again, it may be readily understood that these side reactions consume the battery components, thus reducing the amount of available electric energy which may be secured when the cell is placed in service. The shelf life of the mercury cell is thus limited. The virtual elimination of side reactions in the cells has provided nearly unlimited shelf life in these batteries.

2. The development and use of unique electrode materials have eliminated the necessity of bulky barriers, separators, etc., which are necessary in mercury cells to prevent internal short circuits by the reduced mercury. Thus, the indium cell attains a greater electrical capacity per unit volume through more efficient utilization of available space.

3. A mechanical structure has been designed which holds the various components in correct relationship to one another and provides for leakproof seals at the cell terminals and battery case seams. This is a decided advantage in situations where battery leakage would cause damage.

4. The development of a plastic battery case which occupies a small fraction of the volume required in conventional design is employed in the cell. This important advance greatly increases the available working volume of the cell, thus providing increased battery capacity.

The general specifications for the indium cell are:

1. Long shelf life—at least 1 year prior to being placed in service, plus up to 2 years' service life
2. Essentially constant discharge voltage throughout the service life
3. No leakage permitted throughout shelf or service life
4. No dimensional change during storage or discharge
5. No deterioration on exposure to ambient temperatures in the range of −20 to 190 F
6. Constant characteristics of operation from 0 to 120 F

The specifications listed are the usual requirements for cells in battery-operated instrument, designed for consumer, industrial, and military purposes. The stringent characteristics realized in the Elgin cell render it ideal as a power source in compact battery-operated instruments. The small cells presently being made have a capacity per unit volume which is at least 125 per cent that of mercury cells.

The system being used delivers an open circuit voltage of about 1.15 volts compared to 1.35 volts for the mercury cell. By a simple replacement of the cathode material an open circuit voltage of 1.37 volts may be obtained, which compares closely with that of the mercury cell.

The Elgin cell makes available a battery possessing ultimate reliability and in the smaller sizes a greater energy capacity than comparable mercury cells. In certain forms, the new cell may replace the commercial mercury cells and in others make available a lower voltage cell particularly suitable for transistor circuitry.

COMPARISON with penny illustrates phenomenally small size of new "micro-cell" battery, claimed to be first expendable energy source ever developed that will not leak, swell, or gas. Developed by Elgin National Watch Company, cell is expected to provide a substantially more dependable source of electricity for a wide variety of small, portable, personal devices.

C-Band Radar Developed for Air-Line Operations

The first installation in the $4,000,000 program of United Air Lines to equip its fleet with C-band radar has just been completed on the *Mary O'Connor*, a Convair *340* executive plane.

C-band (5.5 cm) is the first type of radar developed expressly for air-line operations. It reveals weather conditions as far as 150 miles ahead. Focused at apparently solid storms, it shows wide corridors for smooth flight around turbulent areas. Although primarily designed for weather mapping, C-band beams also report surface features, such as lakes and mountains.

(Left) FINAL CHECK of C-band radar on Mainliner O'Connor, a Convair 340 being made by L. E. Sebald, project engineer at the San Francisco maintenance base of United Air Lines. It is the first installation in a $4,000,000 project to equip the company's entire fleet with the new weather-mapping device. With left hand at radar control panel, Mr. Sebald operates tilt control panel which changes horizontal area scanned by antenna. Scope is at center of instrument panel. (Right) Demonstration of antenna of C-band radar on Mainliner O'Connor by L. E. Sebald. The company's entire fleet is being equipped with the new type of radar specifically designed for air line operations. Nose of the plane has been extended to house radar antenna and gear mechanism.

United's communications department began research on the potential of C-band radar 3 years ago. In the summer of 1953 the company conducted 40 technical and operational flights in storm areas, using a *DC-3* test plane and experimental C-band equipment supplied by the Radio Corporation of America.

Early this year United announced plans to outfit its fleet with C-band radar, thus becoming the world's first air line to adopt the device as standard equipment. In March, a $2,500,000 order for 200 air-borne radar units was placed with Radio Corporation of America. An additional $1,500,000 has been earmarked for installation costs.

American Nuclear Society Elects Dr. W. H. Zinn First President

The American Nuclear Society, the world's first professional organization composed of scientists and engineers engaged full-time in the industrial, governmental, and educational aspects of atomic energy, has announced the election of Dr. W. H. Zinn as its first president.

The announcement was made recently at the society's first annual meeting of the membership at Pennsylvania State University. The newly formed organization now has 850 members.

A 30-member board of directors, whose membership includes representatives of every leading atomic energy establishment in the United States as well as from abroad, was also elected. The foreign members of the board of directors include Dr. W. B. Lewis, research director at Canada's Chalk River atomic energy installation, and Dr. Gunnar Randers, Norwegian physicist who is director of the Joint Dutch-Norwegian Nuclear Energy Establishment.

Dr. Zinn, a pioneer in the United States atomic program, is director of the U. S. Atomic Energy Commission's Argonne National Laboratory, Lemont, Ill. He is one of the world's foremost authorities on nuclear reactor design.

Penn State Receives Reactor License From AEC

A license to operate a research reactor and to receive, possess, and use special nuclear materials was issued to Pennsylvania State University on July 8 following an inspection of the completed facility by Atomic Energy Commission representatives.

The application from Penn State was one of 14 applications for licenses to engage in atomic energy activities received by the Commission through June 30, 1955. Ten related to construction and operation of atomic reactors for industrial and medical research and for production of electric power; three were for licenses to possess and use special nuclear materials; and one proposed operation of a fuel element fabrication facility.

The Penn State license, which runs through June 30, 1965, authorized the university to receive and use as fuel up to 3,600 gm of contained Uranium 235, of which approximately 100 milligrams may be used in fission chambers. The university is also licensed to possess such special nuclear and by-product material as may result from operation of the reactor.

Although the Penn State license was the first to be issued by the Commission under the growing program of civilian participation in the development and use of atomic energy for peaceful purposes, the reactor is not the first privately owned facility to go into operation. A research reactor, operated under a Commission contract which is considered to be an interim license, has been in use at North Carolina State College since September 1953. (See EE, Aug '55, pp. 642–4.) An application for formal license from North Carolina State is now under consideration by the Commission.

The Penn State facility, housed on the university's campus, is a low-power "swimming pool" type of reactor used in general nuclear research and experimentation and in the production of short-lived radioactive isotopes. It is cooled and moderated with ordinary water, and uses enriched uranium fuel. The fuel elements are suspended in a pool of water sufficiently deep to serve as a shield against the radiation produced by the reactor. Experience at the Oak Ridge National Laboratory has demonstrated that this type of reactor is relatively inexpensive, safe to operate, and easy to maintain.

Initially Penn State is authorized to operate the reactor at power levels not in excess of 30 watts. After the reactor's characteristics have been determined and upon completion of experiments to determine the value of control and safety elements, it is contemplated that a higher power level will be authorized.

New Electronic Writer Reproduces Writings Accurately

The electronic writing device which has been developed by Autron Engineering, Inc., is a simple low-cost rugged system for transmitting instantaneously any type of written intelligence from a transmitter to a remote receiver. The system does not require the use of any intermediate steps between the actual writing and the transmission of said writing. The user writes directly on paper at the transmitter and this writing is instantaneously reproduced at the receiver.

The device is capable of accurately reproducing normal, fast handwriting, drawings, maps, numerals, or any other written intelligence. Ball point pens are used at both the transmitter and receiver, and permanent smudge-proof records are available as well as carbon copies when required. Letters and numerals as small as 3/32 inch are reproduced clearly at the receiver. For map drawing or form writing, precisional accuracies of 1/16 inch are readily obtained.

The instrument can take any one of three forms, depending upon the requirements of the installation and the user. They are as follows:

1. A local machine wherein the transmitter and receiver are located within 2 miles of each other. In this installation the customer-installed cable is used for interconnection.

2. A long lines machine wherein the transmitter and receiver are a considerable distance apart, however, located such that they can be connected by voice channel long lines telephone wire.

3. A wireless machine wherein the transmitter and receiver are located at such a distance apart that FM wireless communication can be used. This equipment is particularly adaptable to air-to-ground transmission.

Autron Engineering, Inc. has developed and manufactured pre-production models of the local machine. The design of the long lines system is underway and the basic system research for the wireless device has been completed. The three systems use the same basic originating and slave receiving units.

The basic local machine shown in the accompanying photograph consists of a transmitter (12 by 8 by 3 inches), a receiver (12 by 8 by 8 inches), and an amplifier (12 by 9 by 5 inches). The units are compact, and are so designed as to operate for long periods of trouble-free time with little or no maintenance. The long lines and wireless machines required additional equipment over and above the basic equipment required by the local machine, consisting of an electronic chassis (approximately 16 by 14 by 10 inches) at both the transmitting and receiving end.

ELECTRONIC WRITER is demonstrated by Alice O'Buckley as R. E. Poole, Jr., president of Autron Engineering, Inc., reads message as it is being transmitted. The electronic writer, operating on ordinary alternating current, accurately transmits to remote receiver figures and formulas, messages, and maps.

Research on Thunderstorms Is Undertaken in Florida

Scientists assigned to the Air Research and Development Command commenced balloon launchings early in July in the central Florida region to study the electric charges set up by thunderstorms. The scientists are from the Geophysics Research Directorate of the Air Force Cambridge (Mass.) Research Center, and they launched their balloons from Orlando Air Force Base in Florida. This site was selected because it is the scene of frequent thunderstorms during the summer months. In carrying out the field experiments, balloons are launched from Orlando Air Force Base just prior to the full development of a thundercloud. Balloons float horizontally over the thundercloud at a specified altitude between 60,000 and 100,000 feet.

Instruments taken aloft by the balloons gather information on the electric field and currents produced by the thundercloud, and also on the change of electric field and currents caused by lightning discharges to the ground or other charged centers.

The electrical information is telemetered to ground-based receivers, where scientists gather the information for future studies, seeking basic facts about the tremendously powerful electric impulses that are generated.

The findings will be of great value to Air Force pilots, weather forecasters, and communications experts.

While Orlando Air Force Base is the scene for balloon operations, two other Air Force bases in the south are aiding in the project. Radar stations at Patrick Air Force Base, Cocoa, Fla., and at Pinecastle Air Force Base, also in Orlando, check the height and position of the thunderclouds, and track the balloons in flight.

In addition, the effect of lightning discharge on the normal earth's electric field are being studied. This phase of the operation is conducted simultaneously with the balloon investigations. Instruments mounted on mobile trucks are used in the lightning discharge tests.

Representatives from the General Mills Company and the Minneapolis-Honeywell Company, working under contract to the Air Force, also are participating in the tests, which will be concluded after a total of nine balloon flights.

NEW BOOKS . . . . .

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

STARKSTROMTECHNIK. Part III. By E. v. Rziha. Wilhelm Ernst and Sohn, Berlin, Germany, eighth edition, 1955. 379 pages, 8¼ by 5⅞ inches, paper. DM 23.00. This part 3 concludes the first volume of a proposed 2-volume set on heavy-current technology. It contains chapters on steam, hydroelectric, and wind-motor plants, their planning, machinery, switchgear, and selective protection. The index and table of contents to all of volume 1 come with this concluding part.

SUPERFLUIDS Volume I: Macroscopic Theory of Superconductivity. 1950, 161 pages, $5.75 Volume II: Macroscopic Theory of Superfluid Helium. 1954, 217 pages, $8.00. By Fritz London. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. 9¼ by 6 inches, bound. Volume I of this set presents an electrodynamic theory of superconductivity in metals at very low temperatures, while volume 2 presents a theoretical interpretation of the more relevant properties of superfluid helium, that is, liquid helium below 2.19° absolute. The general features of low-temperature superflow phenomena are discussed, and the electric, magnetic, thermodynamic, and physical properties exhibited are explained by a thoroughly worked-out theory based on quantum mechanics.

TABLES OF SINES AND COSINES FOR RADIAN ARGUMENTS. (Applied Mathematics Series, no. 43) National Bureau of Standards. Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C., 1955. 278 pages, 10½ by 8 inches, bound. $3.00. Sine and cosine values are given to eight decimals, at intervals of 0.001, over a range of 25.2 radians, the approximate equivalent of four complete circles. An introductory section describes methods of both direct and inverse interpolation. This is a reissue of Mathematical Table MT4 of the WPA series, with an extension of the range and a few corrections and changes.

DIE THEORIE DES NEBENSPRECHENS AUF LEITUNGEN. By Wilhelm Klein. Springer-Verlag, Berlin, Germany, 1955. 135 pages, 9¼ by 6⅛ inches, paper. DM 18.00. A mathematical treatment of crosstalk in carrier-frequency lines, with some application of the theory to technical problems. A considerable range of cable types and physical arrangements of lines is considered. A brief introduction to matrix algebra is appended.

TRANSACTIONS OF THE SYMPOSIUM ON COMPUTING, MECHANICS, STATISTICS AND PARTIAL DIFFERENTIAL EQUATIONS. (Second Symposium on Applied Mathematics) Sponsored by the American Mathematical Society and Office of Ordnance Research, U. S. Army. Interscience Publishers, Inc., 250 Fifth Avenue, New York 1, N. Y., 1955. 216 pages, 10½ by 7 inches, bound. $5.00. The 11 papers included deal with recent advances in such fields as operations research, statistics, computing, mechanics, and partial differential equations. Typical topics dealt with include iterative computational methods, the simplest rate theory of pure elasticity, and the stability of mechanical systems. The volume is a reprint from the journal *Communications on Pure and Applied Mathematics*.

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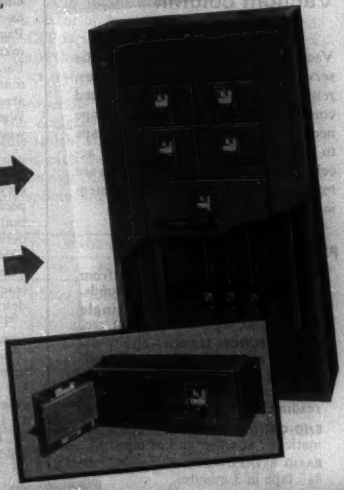

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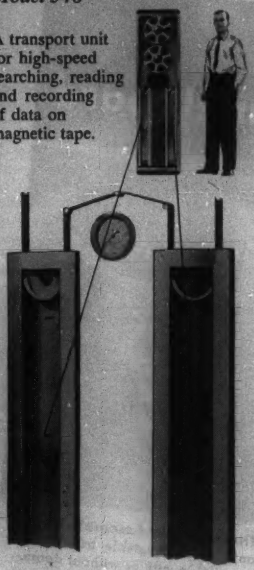

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ElectroData Corporation maintains a nation-wide sales and service organization.

INDUSTRIAL NOTES ....

General Electric News. More thorough factory tests, simulating actual operating conditions, can now be performed on large rotating electric equipment up to 70,000 kva in the General Electric Company's new test center at Schenectady, N. Y. The $1,000,000 center, part of the General Electric large motor and generator department's $8,000,000 expansion program, makes possible the testing of synchronous condensers up to 70,000 kva. Large hydro-generators can be assembled and tested before shipment, instead of after installation. Large d-c motors and generators can be tested in the factory, and large a-c synchronous and induction motors and generators can be tested by the zero power factor method, under conditions more severe than are encountered in the field.

Increased sales effort in the television-broadcasting-equipment industry was promised with disclosure of the reorganization of the company's national sales force. The reorganization involves creation of new positions, and naming of new district sales managers. Territorial sales assignments have also been changed. The new appointments are John Wall of Cincinnati, Ohio, as northeast regional manager; Charles T. Haist of San Francisco, Calif., as western regional manager; Lewis F. Page of Washington, D. C., as district manager in the Virginia-Maryland area; Earl H. Platt of Syracuse, N. Y., as district manager in the Kentucky–West Virginia area; and Vernon H. Russell of Seattle, Wash., as district manager for the northwestern states.

Westinghouse to Build 'Automatic' Factory. A new Westinghouse Electric Corporation manufacturing plant will be built at Youngwood, Pa., and will employ between 400 and 500 persons by the end of 1956. The multimillion dollar plant will manufacture semiconductor devices such as transistors, power rectifiers, high-frequency detectors, and photocells.

The facility will be operated by the company's newly formed semiconductor department. Manager of the new department and plant will be L. R. Hill. Other key appointments include: Dr. S. J. Angello, manager of engineering; Dr. L. L. Friend, manager of manufacturing; W. L. James, manager of sales; and C. H. Hildebrand, purchasing agent.

Pittsburgh Reflector to Expand Production. Pittsburgh Reflector Company is establishing a new division to produce Luma-Ceiling and church lighting equipment. Eric D. Altree will head this newly established division. Harold D. Siler will succeed Mr. Altree as manager of the engineering department.

Siegler Buys Electronics Firm. The Siegler Corporation of Centralia, Ill., has purchased the outstanding stock of the Hallamore Manufacturing Company of Long Beach, Calif. Hallamore manufactures electronic devices used on communication systems, and electronic remote-control and testing equipment. The business and property will be operated by The Siegler Corporation as a separate division known as Hallamore Electronics Company. Lloyd G. Hallamore, founder of the electronics firm, will continue to head the division.

Assistant Director Named. The appointment of Donald E. Moat as assistant director of marketing of the Leeds and Northrup Company has been announced. Formerly district sales manager in the Leeds and Northrup Cleveland office, Mr. Moat will be acting head of the marketing department in Philadelphia, Pa., succeeding the late L. E. Emerich.

Syntron Sales Company Changes. Five of the sales companies handling the sales of Syntron equipment have announced changes in their sales organization. Syntron St. Louis, Mo., Sales Company has appointed Aubrey Nickels to their sales staff. Leon P. Hauck has been appointed salesman for the Syntron Buffalo, N. Y., Sales Company. Employed as a store salesman, Stanley Matejek will be located at Syntron Power Tool Company in Hasbrouck Heights, N. J. Frank Bellettieri, has been promoted to vice-president of Syntron Irvin Sales Company, Indiana, Pa., succeeding David Irvin, who recently resigned. Syntron Philadelphia, Pa., Sales Company has named Graham Bell as power tool salesman in the Philadelphia, Eastern Pennsylvania area.

National Advertising Manager. Richard Berggren has been named national advertising manager for Hoffman Radio Division, Hoffman Electronics Corporation. Mr. Berggren will co-ordinate the national advertising program for the Hoffman line of television, radio, and high-fidelity phonograph equipment, and will be working closely with the company's distributors in the development of specialized advertising and sales promotion programs. Deane Aylesworth will continue as advertising manager for Hoffman Laboratories, Inc., wholly owned subsidiary engaged in the design and manufacture of advanced electronic systems and radiometric equipment.

Minnesota Electronics Corporation Moves. The Minnesota Electronics Corporation, a subsidiary of Librascope, Inc., has moved its entire operation from St. Paul, Minn., to 133 East Santa Anita Avenue, Burbank, Calif. Although the Minnesota Electronics Corporation will operate independently, the move is de-

(*Continued on page 15A*)

(Continued from page 14A)

signed to strengthen the engineering skills of both companies. Plans call for continuation and expansion of the corporation's work on its proprietary item, the Decision Element. In addition, the corporation has announced the completion of a new building at 520 Dyer Road, Santa Ana, Calif., to house its Mecca Division.

Stromberg-Carlson and General Dynamics Merge. The merger of the General Dynamics Corporation and the Stromberg-Carlson Company has been approved by Shareholders of both firms. W. Kennedy, Jr., has been named vice-president, and Charles W. Pritchard, secretary-treasurer of the newly formed Stromberg-Carlson Broadcasting Corporation. Robert C. Tait, president of Stromberg-Carlson and a senior vice-president and member of the board of directors of General Dynamics Corporation, is chairman of the board of directors of Stromberg-Carlson Broadcasting Corporation. The board will include Mr. Fay, president; Gordon G. Holt, who is executive vice-president of the Stromberg-Carlson Company; Lee McCanne, executive vice-president of the Rochester Chamber of Commerce, and Arthur Stern, attorney, of Nixon, Hargrave, Devans and Dey, will serve as the Stromberg-Carlson Company representatives. Representing the General Dynamics Corporation are Frank Pace, Jr., who is executive vice-president of the General Dynamics Corporation; Earl D. Johnson, senior vice-president—development and operations; Lambert J. Gross, vice-president in charge of finance, and Roger I. Harris, vice-president and counsel.

Vice-Presidents Named. Two new vice-presidents have been appointed by the Warner Electric Brake and Clutch Co., Bellit, Wis. The executives promoted were Norman K. Anderson, formerly general sales manager, who was named vice-president—sales, and King DeSeve, formerly manager of manufacturing, who was made vice-president—operations.

Filtron Opens West Coast Plant. The Filtron Company, Inc., has opened a new West Coast plant at 10023 West Jefferson Boulevard, Culver City, Calif. Plant equipment includes shielded laboratories, screen rooms, and modern test facilities necessary for the design and development of electronic components.

Maxson Instruments Program Announced. The newly formed Maxson Instruments Division of The W. L. Maxson Corporation has reported plans to expand its line of precise measurement and control equipment. The new division is headquartered at 47-37 Austell Place, Queens, N. Y., under the direction of Frederick H. Rohrig, as general manager.

New Company Organized. A new company has been organized for the manufacture of printed circuits and printed circuit

(Continued on page 26A)

RAYONIC
CATHODE RAY TUBES
by Waterman

3XP RAYONIC CATHODE RAY TUBE provides a brilliant and sharply-defined trace and high deflection sensitivity at medium anode potentials. When comparing 3RP operating at 1000 volts second anode against 3XP operating at 2000 volts, the results are astonishing. For the same spot size, 3XP light output is improved by a factor greater than 4, vertical deflection sensitivity improved by a factor of 2, while the horizontal sensitivity remains unchanged. Because 3XP is enclosed in a short envelope and has half the inter-electrode capacities of the 3RP, the tube lends itself admirably to high frequency video work as well as for low repetitive operation.

TECHNICAL DATA The basic properties of the cathode ray tube that concern the designer or the user are: deflection sensitivity, unit line brightness, line width, static voltage requirements and physical size. A comparison between cathode ray tubes manufactured by Waterman Products Company is shown in the table below. These tubes are available in P1, P2, P7 and P11 phosphors. 3JP1, 3JP7, 3SP1 and 3XP1 are available as JAN tubes.

TUBE #	PHYSICAL DATA			STATIC VOLTAGE			DEFLECTION*		LIGHT OUTPUT**
	Face	Length	Base	A3	A2	A2 Max.	Vert	Hor	
3JP1	3"	10"	Med Diheptal	3000	1500	2000	111	150	352
3MP1	3"	8"	Sm Duodecal		750	2500	99	104	33
3RP1	3"	9½"	Sm Duodecal		1000	2750	61	86	44
3SP1	1.5x3"	9½"	Sm Duodecal		1000	2750	61	86	44
3XP1	1.5x3"	8⅞"	Loctal		2000	2750	33	80	218

*Deflection in volts per inch.
**Light output of an element of a raster line (one mm long and not exceeding .05mm in width) in microlumens.

All heaters 6.3 V AC, .6 AMP.

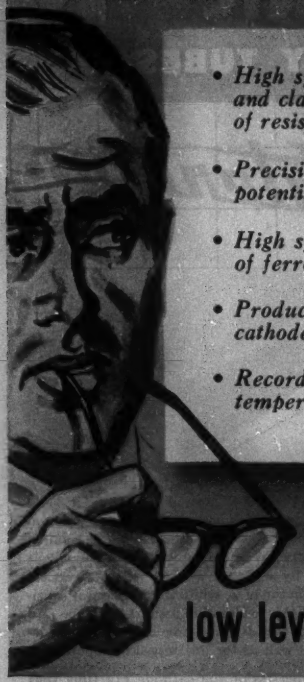
WATERMAN PRODUCTS CO., INC.
PHILADELPHIA 25, PA. CABLE ADDRESS: POKETSCOPE

MEMO... Write for details today!

WATERMAN PRODUCTS

WATERMAN PRODUCTS INCLUDE
3JP1, 3JP7, 3SP1, 3XP1 JAN RAYONIC® Cathode Ray Tubes
3JP—3MP—3RP—3SP—3XP RAYONIC CATHODE RAY TUBES
Available in P1, P2, P7, and P11 Phosphors
POCKETSCOPES® PULSESCOPES® RAKSCOPES®
And Other Associated Equipment

These or similar problems puzzling you?



- *High speed inspection and classification of resistive elements*
- *Precision control of minute potentials and currents*
- *High speed inspection of ferromagnetic materials*
- *Production testing of cathode ray tube brightness*
- *Recording extremely low temperature differentials.*
- *Continuously recording rate of temperature change in jet engine test stands*
- *R.M.S. regulation of a-c oscillators and generators*
- *Multiplication of two a-c or d-c signals to provide a precision product*
- *Precision low power factor measurements for production inspection of transformers and motors*

The INDUCTRONIC® SYSTEM of low level MEASUREMENT and CONTROL

Model 1475 Multi-Range Inductronic D-C Amplifier provides amplification of a complete span of direct current and voltage ranges of either polarity with no sacrifice in fundamental accuracy or speed. Has seven current ranges, from 10 to 1,000 microamperes — and ten voltage ranges, from 1 to 1,000 millivolts. All ranges immediately available by the turning of a switch; and an additional seventeen ranges become available by a knob adjustment which changes the instrument from zero left to zero center. Accuracy 1%. Accessories such as recorders and additional indicators can be inserted in the output to a total of 5,000 ohms without affecting accuracy or calibration.

Practical solutions to the above, and many other problems of low-level measurement and control have been supplied by the WESTON Inductronic System . . . an entirely *different* method of d-c amplification. Utilizing the deflection of a permanent magnet moving coil system, it converts extremely low-level d-c to a proportionate a-c signal and amplifies it to a *usable degree* . . . then reconverts to a d-c level. The system operates at a frequency of 200 KC, and provides a high order of sensitivity, accuracy and speed. And because of circuit simplicity, the system is stable and virtually maintenance free. To learn how you can apply the Inductronic System in research or production, call your nearest Weston representative, or write direct for bulletin B-36-B.

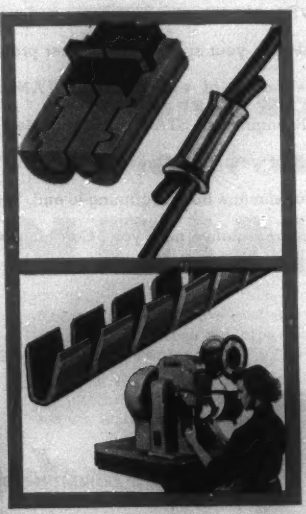
WESTON *Instruments*

WESTON ELECTRICAL INSTRUMENT CORPORATION, 614 Frelinghuysen Avenue, Newark 5, New Jersey

...but here it is!

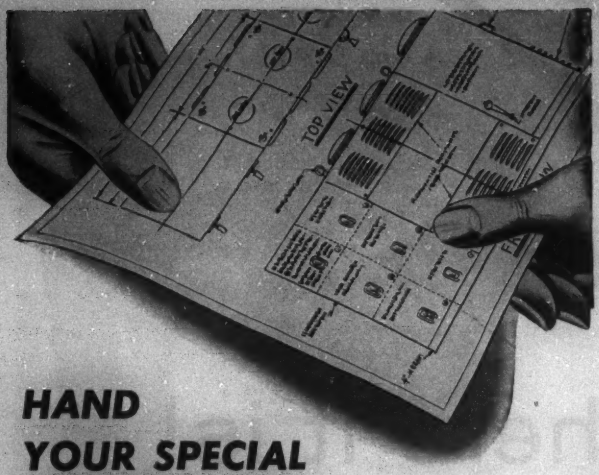
AMPli VAR Splice

At last, a termination that splices enamel, polyvinyl acetal and similarly coated wire! No more scraping, no more dipping in solvents, no more damaged wire from embrittling or solder wicking when you use new Amplivar splices. They're faster too; can be applied at a high rate of speed with AMP automatic machines. Amplivar splices are scarcely larger than the wires they connect yet mean more reliable, more uniform terminations of coil windings in your product. Positive multi-ring stripping with Amplivar Keystone Serration splices assures a perfect electrical connection.



AMP®

AIRCRAFT-MARINE PRODUCTS, INC., 2100 Paxton Street, Harrisburg, Pa.
In Canada: AIRCRAFT-MARINE PRODUCTS OF CANADA, LTD., 1764 Avenue Road, Toronto 12, Ontario, Canada



HAND YOUR SPECIAL TRANSFORMER PROBLEMS TO...

Standard
TRADE MARK

YOU CAN SAVE many valuable man-hours and production hours by placing your special transformer problems in the capable hands of experienced STANDARD TRANSFORMER engineers. STANDARD engineers can easily detail all of your transformer requirements and oversee their manufacture from beginning to end. There's a STANDARD representative near you. Call him today!

300 KVA indoor unit sub-station or load center, consisting of high voltage, fused air brake switch and low voltage section with circuit breakers and transformer

The Standard
WARREN, OHIO
REPRESENTATIVES IN PRINCIPAL CITIES

(*Continued from page 15A*)

assemblies known as Eaton Associates, Inc., Moodus. Conn. Joseph O. Eaton is the principal shareholder in the company. Associated with him are Daniel Dewey of Essex, Conn.; Samuel Pear of Moodus, Conn.; Frank E. Taplin of Williamstown, Mass.; A. E. Griffin of Winstead, Conn.; and H. D. Randall of Westerly, R. I. Mr. Eaton, Mr. Dewey, and Edward A. Stoll of Deep River, Conn., corporation counsel, are the directors.

Ronson Acquires Hydraulic Units. Hydraulic Units, Inc., of Pasadena, Calif., has been acquired by Ronson Corporation as part of their diversification and expansion program. Ronson's Air Products Division, Newark, N. J., now has modern aircraft parts manufacturing plants on both the East and the West Coast to serve the requirements of major airframe and engine manufacturers. Byron D. Gilmore and Harry E. Johnson, president and vice-president, respectively, of Hydraulic Units, Inc., will continue in active management as officers.

Curtiss-Wright Purchases Elly Electronics. Curtiss-Wright Corporation has purchased the Elly Electronics Corporation in an expansion of its Electronics Division. J. George Sauer, president of Elly Electronics, has joined the Electronics Division in the position of manager—thermal devices sales, and all employees of the former company have been retained by Curtiss-Wright. The Curtiss-Wright Electronics Division, of which J. R. Pascuzzo is general manager, is located in Carlstadt, N. J.

Frerer Appointed Vice-President. Paul G. Frerer has been appointed vice-president—director of engineering, of Soreng Products Corporation. Mr. Frerer previously held the position of chief engineer.

Executive Vice-President Named. Ernest M. Hall, Jr., has been named executive vice-president of Electro-Technical Laboratories, Inc., 504 Waugh Drive, Houston, Tex. In his new post, Mr. Hall will handle sales and engineering activities of the company.

Philadelphia Electric Change. Philadelphia Electric Company has recently moved into its new, $3,000,000 Oregon Maintenance Shops building at Delaware and Oregon Avenues, opposite the company's Southwark electric generating station, in southeast Philadelphia, Pa. The building will serve the combined shop requirements of the Operating Maintenance Division of the station operation department, and the Construction Division of the engineering department.

Engineer Named Vice-President. James C. Hoiby has been appointed vice-president—engineering, of the D. W. Onan and Sons, Inc. Mr. Hoiby, formerly chief engineer of the firm, has been associated with the company since 1934. In his new appointment he will be in charge of the re-

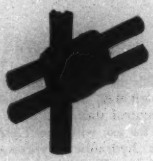
(*Continued on page 30A*)

TYPE GA-H—CABLE TO H-BEAM FENCE POST—*This grounding connector joins wide range of standard H-beam posts to fence fabric and cable. Range of cables easily accommodated. Sizes available for grounding more than one cable. One-wrench installation.*

TYPE GD—2 CABLES TO PIPE
Clamp-type ground connector for joining range of two equal cables or single looped cable to pipe or column. Especially convenient for grounding fence posts. Wide range of sizes.

TYPE GX—CROSSED WIRES OR CABLES—*Simple, rapid connection, easy to inspect. Recommended for crossing ground conductors in order to secure greatest efficiency in reducing voltage gradient. Connector takes wide range of sizes.*

TYPE GB—CABLE TO FLAT SURFACE
Connects wide range of ground lead cable to flat structural or equipment surfaces. Can be furnished with larger than standard size bolts for pre-punched holes in steel work. One-wrench installation.



TYPE GP—2 PARALLEL CABLES 90° TO GROUND ROD—*Clamp-type connector joins two parallel cables at right angle to ground rod, pipe, or column. Accommodates range of cable sizes in each groove.*

TYPE GAR—CABLE TO ROD OR PIPE...PARALLEL OR 90°
Double-purpose ground connector—joins ground bus to rod or pipe either parallel or at right angles. Easily installed by tightening two nuts on U-bolt. Accommodates wide range of cable.

TYPE GK—3 EQUAL CABLES TO GROUND ROD OR PIPE—*This connector is frequently used to join grounding conductor, grounded member, and looped ground bus, at one point. Accommodates wide range.*

TYPE GG—BRAID, BAR, LEAF, OR CABLE TO PIPE—*Joins flat flexible braid or copper bar to ground pipes, fence posts, and columns. Highly effective for grounding operating rods, switch handles, gate posts. Can be used with stranded cable by splaying ends under clamp.*

TYPE YA (NYLUG)—GROUND CABLE TO FLAT BAR—*Compression connector—one-piece terminal, easily and economically installed with Burndy portable Hypress. Available for #8 str. to 1000 Mcm.*

9 sound solutions to the problem of

GROUNDING

Engineered to the same precise standards as connectors that carry continuous current loads . . . Burndy grounding connectors can be depended on to provide permanent protection against

• ARC-OVERS • ELECTRICAL LEAKAGE
• LIGHTNING • DIRECT SHORT CIRCUITS

These nine designs are available in 30 variations for connection to driven rod, pipe, cable, fence post, structures, lamp standards.

Send for the Burndy Grounding Catalog, which offers an interesting technical discussion on approved techniques, methods, and materials for proper grounding.

BURNDY

NORWALK, CONNECT. FACTORIES: NEW YORK, CALIFORNIA, TORONTO EXPORT: PHILIPS EXPORT CORPORATION TORONTO, CANADA 54-1

UHF
. . . Ultra High Frequencies

RADIO INTERFERENCE
and FIELD INTENSITY *
measuring equipment

Stoddart NM-50A • 375mc to 1000mc

Commercial Equivalent of AN/URM-17

ULTRA-HIGH FREQUENCY OPERATION . . . Frequencies covered include UHF and color television assignments and Citizen's Band. Used by TV transmitter engineers for plotting antenna patterns, adjusting transmitters and measuring spurious radiation.

RECEIVING APPLICATIONS . . . Excellent for measuring local oscillator radiation, interference location, field intensity measurements for fringe reception conditions and antenna adjustment and design.

SLIDE-BACK CIRCUIT . . . This circuit enables the meter to measure the effect of the peak value of an interfering pulse, taking into account the shaping due to bandwidth.

QUASI-PEAK FUNCTION . . . An aid in measuring pulse-type interference, the Quasi-Peak function is just one of the many features of this specially designed, rugged unit, representing the ultimate in UHF radio interference-field intensity equipment.

ACCURATE CALIBRATION . . . Competent engineers "hand calibrate" each NM-50A unit. This data is presented in simplified chart form for easy reference.

SENSITIVITY . . . Published sensitivity figures are based on the use of the NM-50A with a simple dipole antenna or RF probe. However, the sensitivity of this fine instrument is limited only by the antenna used. The sensitivity of the NM-50A is better than ten microvolts across the 50 ohm input.

Stoddart RI-FI* Meters cover the frequency range 14kc to 1000mc

VLF
NM-10A, 14kc to 250kc
Commercial Equivalent of AN/URM-68. Very low frequency.

HF NM-20B, 150kc to 25mc
Commercial Equivalent of AN/PRM-1A. Self-contained batteries, A.C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies. Has BFO.

VHF
NM-30A, 20mc to 400mc
Commercial Equivalent of AN/URM-47. Frequency range includes FM and TV bands.

STODDART AIRCRAFT RADIO Co., Inc.
6644-B Santa Monica Blvd., Hollywood 38, California · Hollywood 4-9294

(*Continued from page 26A*)

organized Engineering Division, including both production engineering and development, and design.

Sitzer Named Chief Engineer. Hermetic Seal Products Company, 29–37 South Sixth Street, Newark 7, N. J., has announced the appointment of Philip Sitzer as chief engineer. Mr. Sitzer will supervise and control all phases of Hermetic's engineering activity. He joined Hermetic in February 1950.

NEW PRODUCTS . . .

Control Unit. To insure perfect compression installations of insulated and non-insulated terminals on electric cables, from number 8 through 4/0, a new semiautomatic electric control unit, *Y29BUS*, has been developed for use with the *Y29BUS* sliding-rack-type hydraulic Hypress, by Burndy Engineering Company. Readily attached to the Hypress, the *Y29BUS* control provides continuous quality control on all terminal installations. A green light indicates that the terminal installation has been made correctly. Any faulty installation is signaled by a red light and a buzzer in combination; the control unit also prevents further operation of the Hypress until the cause of the stoppage has been eliminated. In addition, the control unit prevents use of the Hypress if the rack is improperly positioned. For more information write Burndy Engineering Company, Inc., Norwalk, Conn.

Automatic Gear Gauge. The Airborne Instruments Laboratory, Inc., Mineola, N. Y., type *80* automatic gear gauge and hobbing machine control operates automatically, sorts gears according to production tolerance limits, and permits control of the hobbing machine so as to prevent production of scrap. Each type *80* gear gauge is custom-designed for particular requirements. Sorting gears according to tolerances established by the user, the type *80* is capable of handling as many as 1,000 gears per hour.

Resistors. Sprague Electric Company's Blue Jacket resistors rated at 3 watts are no larger than conventional 1/2-watt composition resistors. They are ideal for point-to-point, terminal board, and printed chassis wiring, proving advantageous where space is at a premium. Axial lead design assures secure mounting even under severe vibration. A vitreous enamel coating guards against humidity, prevents failure from electrolysis, and resists corrosive industrial fumes. Thermal expansion characteristic of this enamel and the ceramic winding core are closely matched to withstand rapid thermal

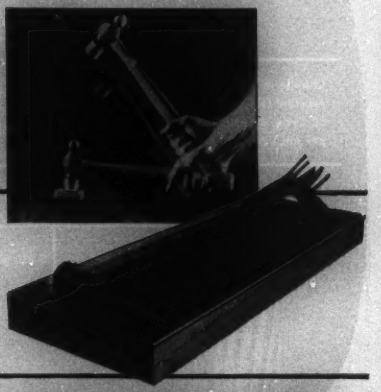
(*Continued on page 32A*)

NEW Silco-Flex MOTOR INSULATION

Offers These Amazing Physical Properties

Allis-Chalmers, working with Dow Corning Corporation, has developed *Silco-Flex* motor and generator insulation . . . truly new in concept . . . truly new in effectiveness.

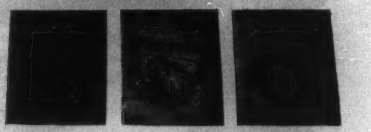
Silco-Flex insulation employs a pure silicone rubber combined with specially developed application techniques to produce an insulation unmatched by any other in use today.



● **Flexibility and Resilience** — *Silco-Flex* insulation remains flexible and resilient indefinitely. It is especially resistant to mechanical abuse and to stresses of overloading, rapid starting and stopping.

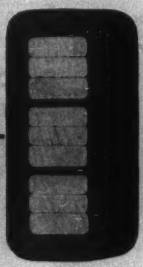
● **Moisture Resistance** — Completely sealed, *Silco-Flex* insulated coils are the most moisture-resistant commercial coils ever produced. They are production-tested while submerged in water . . . by far the most complete and searching high potential test used.

● **Abrasion Resistance** — Samples of insulation at right show effects after sandblasting with 90 grit aluminum oxide and 100 psi air for one minute. Nozzle-to-sample distance was six inches, thickness equivalent to 2300-volt insulation. Note difference in abrasion!



Silco-Flex Insulation | Polyester Mica Tape | Asphaltum Mica Tape

● **Homogeneity** — *Silco-Flex* insulation is a void-free dielectric barrier vulcanized into a unified insulating wall. It maintains its homogeneity under extremes of differential expansion and contraction due to thermal cycling.



Other Advantages include exceptionally good thermal stability and chemical inertness. *Silco-Flex* insulation is also a much better heat conductor than ordinary electrical insulating materials. Moreover, enclosures now required to protect windings from moisture and abrasion may be eliminated in many cases.

New *Silco-Flex* insulation is immediately available for all Class H form-wound coils and for Class A and B windings operating under selected service conditions. For complete information, call your Allis-Chalmers representative or write Allis-Chalmers, Milwaukee 1, Wisconsin.

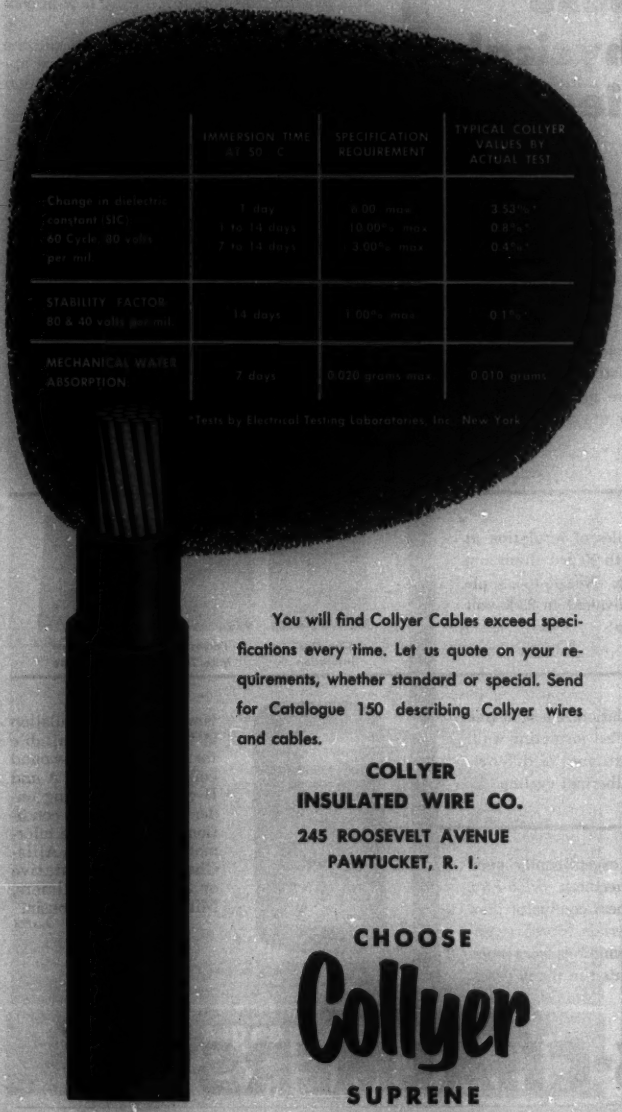
A-4774

Silco-Flex is an Allis-Chalmers trademark.

ALLIS-CHALMERS

Collyer FOR DEPENDABLE MOISTURE RESISTANCE

See how Collyer Standard Network Cable Insulation assures top cable performance in your projects. Immersion tests furnish the evidence:



	IMMERSION TIME AT 50° C.	SPECIFICATION REQUIREMENT	TYPICAL COLLYER VALUES BY ACTUAL TEST
Change in dielectric constant (SIC) 60 Cycle 80 volts per mil	1 day	6.00% max	3.53%*
	7 to 14 days	10.00% max	0.8%*
	7 to 14 days	3.00% max	0.4%*
STABILITY FACTOR 80 & 40 volts per mil	14 days	1.00% max	0.1%*
MECHANICAL WATER ABSORPTION	7 days	0.020 grams max	0.010 grams

*Tests by Electrical Testing Laboratories, Inc., New York

You will find Collyer Cables exceed specifications every time. Let us quote on your requirements, whether standard or special. Send for Catalogue 150 describing Collyer wires and cables.

COLLYER INSULATED WIRE CO.

245 ROOSEVELT AVENUE PAWTUCKET, R. I.

CHOOSE Collyer SUPRENE

(*Continued from page 30A*)

change. The resistors are available in 172 types, rated at 3, 5, and 10 watts, with ohmic values ranging from 1 to 50,000 ohms. Standard resistance tolerance to 50 ohms is ± 10 per cent; over 50 ohms, ± 5 per cent. Complete information is provided in bulletin *M-714*, available from Sprague distributors.

Germanium Power Rectifiers. International Rectifier Corporation has announced the availability of its new germanium power rectifiers. These diffused junction germanium rectifiers are recommended for a-c to d-c power conversion where high-power output, high efficiency, no aging, and small unit size are required. By careful selection of junction characteristics and propitious circuit design, germanium junction rectifiers can be supplied for voltage ranges from 10 volts to 100 kv, and from 10- to 100,000 amperes. The germanium power rectifiers are available in three styles: natural convection, forced convection, and liquid-cooled. For further information, write International Rectifier Corporation, El Segundo, Calif., for bulletin *GPR-1*.

Maintenance Tester. Model *123* maintenance tester checks line voltage, traces continuity in electric circuits, and tests motors with 500 volts for grounds or poor insulation. Since the tester needs no power supply, plant machinery and electric equipment can be checked from power line to motor at the job. Line voltages up to 500 volts a-c are read on a $4^1/_2$-inch meter that is fused against accidental burn-out. Electrical continuity is traced with 6 volts, ample to follow a circuit through burned or pitted contacts. The 500-volt ground test shows the condition of motor insulation on the same scale. For further information write to Slaughter Company, 1700 Nicklin Avenue, Piqua, Ohio.

Switch with Illuminated Push Buttons. A new illuminated push-button switch, featuring an indicating light as an integral part of the button itself, has been announced by Micro Switch of Freeport, Ill., a division of Minneapolis-Honeywell Regulator Company. Low operating force and high pretravel are featured. Identified as catalogue listing *31PB1*, it is provided with a socket inside the heat of the push button for a single-contact miniature bayonet lamp.

Warning Signal. The Pyle-National Company of Chicago, Ill., has announced a new warning signal for use on many kinds of moving equipment. This safety device may also be used to mark the location of hazardous areas where workmen may be hidden from the view of moving equipment drivers or operators. The beam of the type *PAR-46* sealed-beam lamp, used in the new device designated, type *15360* Gyralite, is reflected at right angles by the dual inclined plane reflector which revolves at 48

(*Continued on page 36A*)

announces . . .

the Type 44 Recorder

designed specifically to do what you asked for*

YOU ASKED FOR:

New Performance Standards

FACT—Type 44 Recorder has new, iron-core measuring mechanisms which develop twice the torque of previous designs. This provides faster response, higher fidelity under all operating and load conditions.

Ease of Use and Service

FACT—all parts fully accessible from front of recorder, a particular advantage in flush switchboard mounting.

Less Mounting Space

FACT—recorder has highest ratio of scale width to panel area, is attractive in appearance.

Dependability

FACT—extremely high overload capacity reduces danger of burnouts, promotes longer life. All mechanisms self-shielded against stray magnetic fields.

Economy

FACT—long charts and large ink capacity permit operation for greater unattended periods.

Increased Availability

FACT—carefully coordinated, flexible design permits use of a few basic mechanisms for most applications. These are kept in stock to facilitate prompt delivery. Three kinds . . . flush mounted, projection mounted, or portable . . . available to handle watts, vars, a-c voltage and current, d-c voltage and current, frequency and power factor.

FOR MORE FACTS: CALL *The Man With The Facts* . . . your Westinghouse sales engineer. Or, get your copy of the facts booklet, B-5779, by writing directly to Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania.

*As determined by a user survey of engineers and operating men in all industries.

J-40479

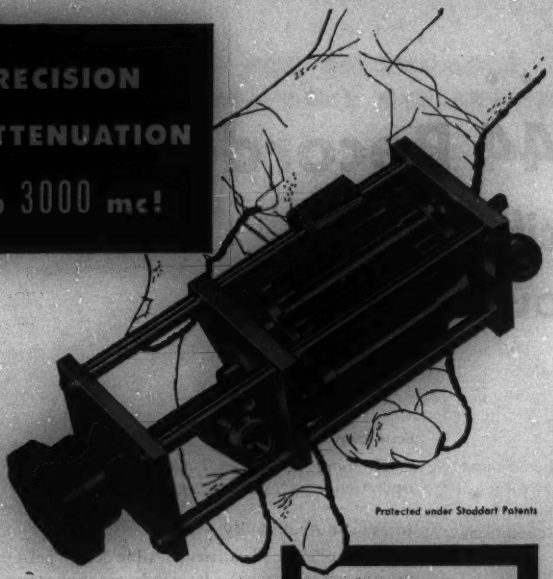
YOU CAN BE SURE . . . IF IT'S Westinghouse

Reliable Recording—high-torque mechanism designs assure accurate, dependable recording. Performance is well within the requirements of ASA Specification No. C 39.2 for recording instruments of the 1% accuracy class.

Convenient—all parts fully accessible from front of recorder, a distinct advantage in flush switchboard mounting. All moving elements are of unit construction, can be removed without disturbing the field circuit.

Protection—extremely high overload capacity is designed into these instruments. For example, improved insulation, conductors, and connections make it possible for the a-c current circuits to carry 100 times rated current for short overloads.

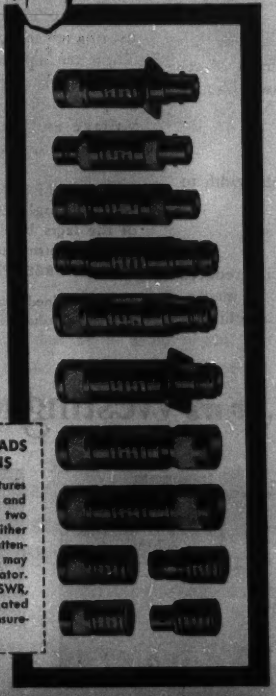
PRECISION
ATTENUATION
TO 3000 mc!



Protected under Stoddart Patents

six-position
TURRET ATTENUATOR
featuring PULL-TURN-PUSH *action*

FREQUENCY RANGE: dc to 3000 mc.
CHARACTERISTIC IMPEDANCE: 50 ohms.
CONNECTORS: Type "N" Coaxial female fittings each end.
AVAILABLE ATTENUATION: Any value from 1 db to 60 db.
VSWR: 1.2 max., dc to 3000 mc/s, values from 10 to 60 db. As value decreases below 10 db, VSWR increases to not over 1.5.
ACCURACY: ± 0.5 db.
POWER RATING: One watt sine wave power dissipation.



SINGLE "IN-THE-LINE" ATTENUATOR PADS and 50 ohm COAXIAL TERMINATIONS

This new group of pads and terminations features the popular Type C and Type N connectors, and permits any conceivable combination of the two styles. For example, the two connector types, either male or female, can be mounted on the same attenuator pad, with or without flanges, so that it may serve as an adapter as well as an attenuator. Frequency range, impedance, attenuation, VSWR, accuracy and power rating are as designated above. Send for free bulletin entitled "Measurement of RF Attenuation."

STODDART AIRCRAFT RADIO Co., Inc.
6644-B Santa Monica Blvd. Hollywood 38, California • Hollywood 4-9294

(*Continued from page 32A*)

rpm and which projects 96 flashes per minute in a horizontal plane. The reflector is mounted directly to the geared motor shaft.

Motor-Generator. G-M Laboratories, Inc., has announced production of a size 11 motor-generator, comprising a standard G-M size 11 precision servo motor and a drag cup generator. Both units are assembled in a single housing. The motor is designed for operation on 115 volts, 400 cycles, but can be wound for other voltages on either phase. The motor has a 0.6-ounce-inch stall torque and a no-load speed of 5,200 rpm. The generator is normally wound for 115-volt 400-cycle excitation, with a residual voltage of 0.019 volts rms and an output voltage of 0.5 volt per thousand rpm.

Shuttle-Car Cable. A new shuttle-car cable with increased life has been announced by the Anaconda Wire and Cable Company. In the cable, a rugged, heat-resistant neoprene insulating compound recommended for operation at 75 C increases resistance to puncture, crushing, and cutting. The cable jacket is also neoprene. Use of this type of insulation and jacket makes the cable highly flame resistant. Greater protection against short circuits is provided in the cable by a patented nylon breaker strip. A high-tensile-strength fibrous open-weave web is used over the insulation and fillers and under the jacket.

Adjustable Growler. Built with adjustable jaws (2½-inch face length) the Martindale type *B-1-M* growler will test armatures from 1 to 18 inches in diameter. Whatever the setting of the jaw opening may be, the armature is always suspended above the center of the jaws, thus preventing tipping. A meter connected to a secondary winding on the growler shows any change in the magnetic flux of the growler. For full information write to The Martindale Electric Company, 1318 Hird Avenue, Cleveland 7, Ohio.

Traveling-Wave Tube Amplifiers. Higgins Laboratories, Inc., Menlo Park, Calif., series of dispersive traveling-wave tube amplifiers features electronic tuning across their respective frequency ranges with 5-db bandwidths from 15 to 20 per cent of center frequency. Tuning is accomplished by varying or sweeping a single voltage without any complementary mechanical adjustments. This type of voltage-tuned amplifier tube should find uses in receiver applications requiring a tunable filter or tunable r-f input to achieve a panoramic display. The narrow band characteristics suggest its use for i-f amplifiers and similar extremely high gain, narrow band amplifier application. The frequency band may be traversed in a fraction of a microsecond.

Resistor. Shallite, Inc., 10 Mill Street, Paterson, N. J., has announced a wire lead precision wire-wound resistor based on transparent encapsulation. The visibility

(*Continued on page 40A*)

Nautilus

first
atomic submarine
uses

TIGER BRAND ELECTRICAL CABLE

The Nautilus was built by General Dynamic Corporation's Electric Boat Division shipyard, at Groton, Conn. She was launched on January 21, 1954.

Very frankly, we cannot recall a more *critical* application of electrical cable than this new atomic-powered submarine. And from one end to the other, this amazing boat is laced with Tiger Brand Electrical Cable.

But here's the important thing—*you* can get the same quality that went into the Nautilus. Just call your American Steel & Wire salesman.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL
GENERAL OFFICES: CLEVELAND, OHIO

COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

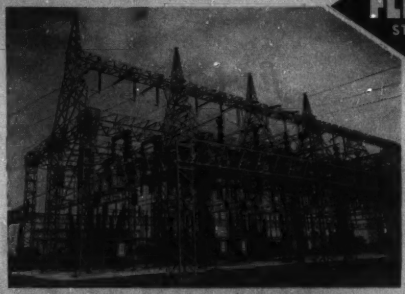
A STANDARD TIGER BRAND CABLE FOR EVERY SPECIAL JOB!

paper & varnished cambric cable
asbestos wire and cable
shovel & dredge cable
mold cured portable cord
machine tool & building wire
special purpose wire & cable
aerial, underground & submarine cable

USS Tiger Brand ELECTRICAL WIRE & CABLE USS

UNITED STATES STEEL

Another Substation by FLINT STEEL



Steel Specialist for the Electrical Industry

The substation shown is just one more example of the completely integrated and personalized service of Flint Steel. Whether the job is large or small, we specialize in *your* requirements . . . from consultation to erection. When you build anything with galvanized structural steel — anywhere — consult us.

FLINT STEEL

TULSA

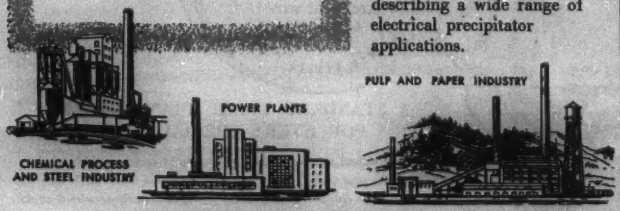
MEMPHIS

Industry looks to

RESEARCH -COTTRELL

for high dust collection efficiencies

To maintain visually clean stacks at all times, industry is turning to the long experience of Research-Cottrell in the design and manufacture of highly efficient Cottrell Electrical Precipitators. We've spent 40 years in solving such problems as nuisance abatement, cleaning gas for subsequent use and recovering materials of value. Write for illustrated bulletin describing a wide range of electrical precipitator applications.



RESEARCH-COTTRELL, INC.

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405 Lexington Ave., New York 17, N. Y. • Grant Building, Pittsburgh 19, Pa.

RC 157 *228 N. La Salle St., Chicago 1, Ill. • 111 Sutter St., San Francisco 4, Cal.*

(*Continued from page 36A*)

feature resulting from the transparent encapsulation assists in precluding service failures caused by bubbles or strains. The resistors include improvements such as the electric welding of wire to the phosphor bronze leads—all completely visible through the transparent encapsulation.

Transistors. Three new alloy-junction transistors of the germanium *p-n-p* type have been announced by the Tube Division, Radio Corporation of America. Two of the new transistors, the *2N77* and *2N105*, have been designed for low-power a-f amplifier service such as in hearing-aid applications. The third type, *2N109*, was designed for use in large-signal audio applications such as class *B* push-pull output stages of battery-operated portable radio receivers and audio amplifiers operating at power levels of approximately 100 milliwatts. All are hermetically sealed, and are enclosed in insulated metal envelopes.

Solenoid Actuator. James Cunningham Son and Company of Rochester, N. Y., has started production of their newly designed electromagnetic solenoid actuator, model *L22A*. Feature of the new actuator is the exclusive Cunningham-designed linkage system available in either a push or pull arrangement, which magnifies the original air-gap movement in an 8-to-1 ratio. The Cunningham *L22A* actuator is compact, displacing 1.4 cubic inches and weighing 50 grams. It operates on 1.8 watts input, within 7 milliseconds at normal voltage. The linkage design permits even motion with minimum friction-induced loss of energy. The actuator remains cool in continuous operation. Coil specifications are 1,260 ohms, 7,400 turns, volts 48 d-c, 0.038 amperes, 1.8 watts; stroke 0.125 maximum; pull 100 to 550 grams.

Automatic Welding Equipment. Complete new automatic, consumable-electrode welding equipment that is adapted for use with low-cost carbon-dioxide shielding gas has been announced by the General Electric Company's welding department at York, Pa. The equipment provides a practical method of using gas-shielded welding for mild steel applications at costs which may be the same or below costs of the submerged-arc process. Consumable-electrode welding of mild steel with carbon dioxide is now out of the experimental stage and is practical for production-line applications. Bulletin GEC *1334* gives complete specifications on this development.

Current Probe. A versatile device for the measurement of r-f current and interference in conductors has been announced by the Stoddart Aircraft Radio Company, Inc., 6644 Santa Monica Boulevard, Hollywood 38, Calif. The Stoddart *91129-1* current probe does not require direct connection to the conductor under measurement. It is an r-f current trans-

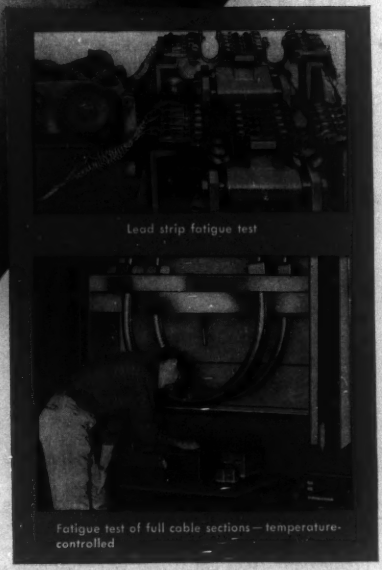
(*Continued on page 42A*)

ROEBLING PAPER POWER CABLE WITH TELLURIUM LEAD ALLOY SHEATH

TELLURIUM LEAD ALLOY SHEATHS MEET ALL REQUIREMENTS FOR FATIGUE RESISTANCE

TODAY'S HIGHER TEMPERATURES and increased loads are power cable problems met most satisfactorily and economically by Roebling Tellurium Lead Alloy Sheath. This sheath has absolutely top fatigue resistance; gives vastly increased service life despite severe bending stresses and cable movement during load cycles. Furthermore, Roebling Tellurium Lead Alloy has outstanding stability under heat—high temperature incurred at joints, terminations and in duct splicing cause no grain growth or physical impairment.

Roebling is unmatched in the breadth of its experience with Tellurium Lead Alloy Sheath and in the volume of cable it has produced with this remarkable sheathing. We will welcome the opportunity to send you Bulletin 205-B containing technical data on Roebling Tellurium Alloy Sheaths.



Lead strip fatigue test

Fatigue test of full cable sections—temperature-controlled

ROEBLING

Subsidiary of The Colorado Fuel and Iron Corporation

JOHN A. ROEBLING'S SONS CORPORATION, TRENTON 2, N. J. BRANCHES: ATLANTA, 934 AVON AVE. • BOSTON, 11-15 STILLINGS ST. • CHICAGO, 5525 W. ROOSEVELT RD. • CINCINNATI, 3253 FREDONIA AVE. • CLEVELAND, 13228 LAKEWOOD HEIGHTS BLVD. • DENVER, 4801 JACKSON ST. • DETROIT, 915 FISHER BLDG. • HOUSTON, 6216 NAVIGATION BLVD. • LOS ANGELES, 5340 E. HARBOR ST. • NEW YORK, 19 RECTOR ST. • ODESSA, TEXAS, 1920 E. 2ND ST. • PHILADELPHIA, 230 VINE ST. • PITTSBURGH, 1723 HENRY W. OLIVER BLDG. • SAN FRANCISCO, 1740 17TH ST. • SEATTLE, 900 1ST AVE. S. • TULSA, 321 N. CHEYENNE ST. • EXPORT SALES OFFICE, 19 RECTOR ST., NEW YORK 6, N. Y.

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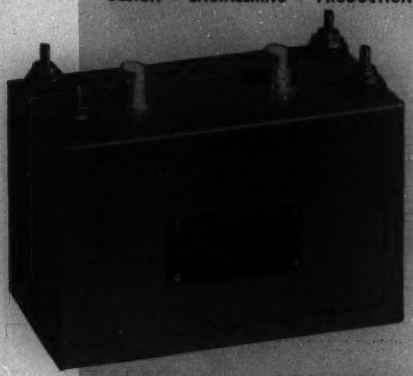
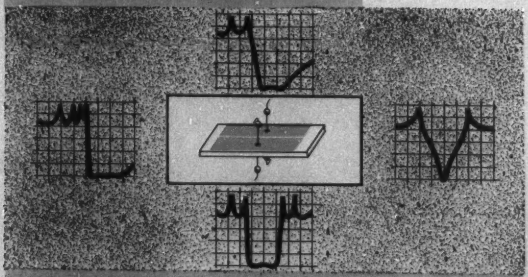


CRYSTAL FILTERS



FREQUENCY RANGE: 10 kilocycles to 10 megacycles for all types of filters.

BANDWIDTH RANGE: 0.01% to 14% of center frequency.

APPLICATIONS: Carrier Communication Systems: Telephone Channel Filters, Pilot Selection Filters, Telemetering Channel Filters, Teletype Channel Filters, Other Frequency Multiplexing Systems. Single Side Band Filters. High Selectivity Amplifiers. Noise and Sound Analysers. Carrier Current Systems. Harmonic Selection.

ANNOUNCEMENT is made of a new technique for the synthesis of crystal filters which resolves many of the problems heretofore associated with their design and production. High initial cost and long lead time have been eliminated. System design no longer need be compromised because of the limited number of existing filters. Filters can be produced on short notice in large or small quantities to meet *exact* performance requirements. Curves shown above suggest the wide variety of characteristics. *Your inquiry is invited.*

HYCON EASTERN, INC.

75 Cambridge Parkway, Dept. C, Cambridge 42, Massachusetts

(*Continued from page 40A*)

former of the inserted-primary type and has a nominal output impedance of 50 ohms. The probe has two semicircular insulated windings on a hypersil core. These are hinged, and by opening the probe the conductors may be placed in its center. A locking arrangement holds the probe closed. The probe is usable from 20 cycles to 25 megacycles and is designed for use with the Stoddart *NM-10A* and *NM-20B* radio interference-field intensity measuring equipments.

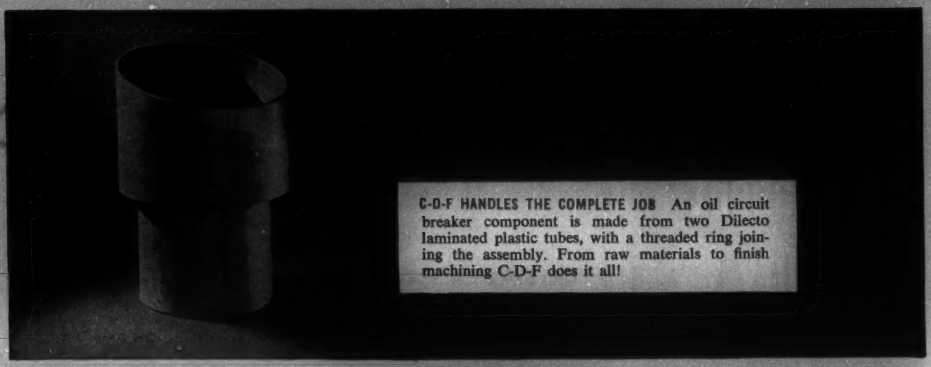
Oscillator. Two new features are available on the General Radio type *1210-B* unit *R-C* oscillator. Square-wave output is provided over the entire frequency range from 20 cycles to 500 kc, in addition to two sine-wave outputs. The square-wave output is 0 to 30 volts peak-to-peak with about 1/4-microsecond rise time. Output impedance is 2,500 ohms. A sine-wave output of 0 to 7 volts is available from a 50-ohm output impedance with no-load distortion less than 1 per cent from 200 cycles to 200 kc. A maximum of 45 volts is available from a 12,500-ohm output. Automatic recording of frequency characteristics is made possible by the second feature. The gear-drive precision dial is arranged so that it is driven automatically by a type *908-P* synchronous dial drive. This motor drive can sweep any portion of each of the 5-decade frequency ranges. Several methods of synchronizing the sweeping with pen recorders can be used to give permanent records of frequency response. With a cathode-ray oscillograph the frequency characteristics of a network can be displayed when a type *1210-P1* detector and discriminator is used with the oscillator to provide a horizontal-deflection voltage proportional to frequency.

Sylvania Fixture. A new lighting fixture designed to illuminate chalkboards has been announced by Sylvania Electric Products Inc., New York, N. Y. The fixture provides abundant light over the entire writing surface and is useful wherever vertical surfaces require supplementary light. The chalkboard fixture line is available in 4-, 8-, and 16-foot lengths in rapid and instant start.

TRADE LITERATURE

Bulletin of Network Protectors. "Network Protectors for A-C Secondary Network Systems" is the title of a new General Electric Bulletin. Designated *GEA-2017E*, the 28-page bulletin covers all phases of a-c secondary networks. Illustrations include diagrams, charts, and photographs of the units and their components, with detailed description of their operation. Also included are discussions of fuses and

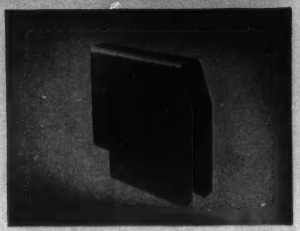
(*Continued on page 50A*)



C-D-F HANDLES THE COMPLETE JOB An oil circuit breaker component is made from two Dilecto laminated plastic tubes, with a threaded ring joining the assembly. From raw materials to finish machining C-D-F does it all!

C-D-F KNOWS HOW TO MACHINE PLASTICS. A bus bar gets a covering of molded Dilecto over copper supplied by the customer. The plastic ends are skillfully trimmed on a smooth saw.

C-D-F MOLDS MANY SPECIALTIES. This shaft insulator for a circuit breaker is molded from C-D-F's cloth-based industrial thermosetting plastic, Celoron. Note complexity of mold, clean detailing.



C-D-F USES MODERN METHODS. Large quantities of arc chute barriers are made from paper-based Dilecto. Operations include pressing, cutting, post-forming and trimming.

Dependable equipment relies on C-D-F insulation!

C-D-F OFFERS UNIQUE MATERIALS. This contact shaft for an air circuit breaker is another example of molded C-D-F Celoron used in switchgear because of its high impact strength.

C-D-F IS A SKILLFUL ASSEMBLER. Made from Grade C rolled Dilecto tubing, these pots are turned, bored, slotted. Then a macerated plastic end is inserted and arc resistant varnish finish applied.

C-D-F UNDERSTANDS THE ELECTRICAL INDUSTRY'S NEEDS. Precisely machined to close tolerances, Dilecto panel boards guarantee dependable insulation, help designers save space.

See our catalog in Sweet's Design File for basic product data and sales offices. Write for detailed information, or send us your print for quotation.

CDF *Continental-Diamond Fibre*

CONTINENTAL-DIAMOND FIBRE DIVISION OF THE BUDD COMPANY, INC.

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Closely Regulated
D-C Power Source of
Permanent
Stability

C&C

STAVOLT®
POWER
RECTIFIERS

- Greatly simplified circuit with fast responding magnetic control of highest reliability.
- No warm-up time, no hunting or drifting.
- Lighter weight, more compact, rugged and field proven. Encapsulated components.
- 11 standard models up to 1500 amps. Meets Spec. MIL-E-7894.

Write for interesting information on STAVOLT rectifiers.

McCOLPIN-CHRISTIE CORP.
Specialists in Rectifier Manufacturing for 26 Years

Measurements Corporation

MODEL 111

CRYSTAL CALIBRATOR

For The Frequency Calibration Of Equipment In The Range Of

250 Kc. to 1000 Mc.
(To within .25 Mc.)

Frequency Accuracy: ±0.002%

The Model 111 provides a test signal of crystal-controlled frequency and has a self-contained detector of 2 microwatts sensitivity.

For calibration and frequency checking of signal generators, transmitters, receivers, grid-dip meters, etc.

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(*Continued from page 42A*)

relays in network protectors. Complete specifications of all types are included. Requests for the bulletin should be addressed to General Electric Company, Schenectady 5, N. Y.

Raytheon Bulletin. Raytheon bulletin *3-110* describes the new Raytheon *KTR-100* system of color television microwave relaying. The *KTR-100* provides one basic system for both color and monochrome transmission with built-in multiplexed audio signals, and can be used as either a permanent or portable link for *STL* and remote pickups. It is adaptable to all bands. The literature gives data on applications, performance, specifications, and accessories. For copies of this bulletin write to: Bernard Levin, Technical Information Representative, Equipment Marketing Division, Raytheon Manufacturing Company, Waltham, Mass.

Shock and Vibration Bulletin. Robinson Aviation, Inc., Teterboro, N. J., has just published a booklet entitled "A New Concept in Vibration and Shock Control for Airborne Electronic Equipment." This free publication is available to engineers, designers, and manufacturers of the devices which safeguard pilots and passengers. For copies of bulletin *900*, write to the manufacturer.

High-Strength Steels. A new publication by United States Steel, "Design Manual for High Strength Steels," is available as a working handbook for architects and engineers. The booklet contains numerous charts and formulas, not only for high-strength steels, but also for structural carbon steel, and can be used as a multi-purpose design manual. The manual may be obtained by writing to United States Steel Corporation, 525 William Penn Place, Pittsburgh, Pa., referring to publication number *ADVL-215-54*.

Device for Selecting Switch and Bus Insulators. An easy-to-use circular slide chart, called the Locke switch and bus insulator selector, has been developed for the convenience of utility engineers and apparatus manufacturers by the Locke Department, General Electric Company, Baltimore, Md. It enables the user to determine quickly the mechanical and electrical characteristics of cap- and pin-type insulator stacks for given operating voltages, and basic impulse insulation levels. Upon turning the selector to a specific operating voltage (from 7.5 to 380 kv), one may read the technical reference number, stack height, leakage distance, dry arcing distance, bolt circle, rated impulse withstand, low-frequency and impulse flashover, and low-frequency withstand characteristics. In addition, cantilever strength, tension, torsion, and compression ratings are shown. The insulator selector may be obtained through Locke sales representatives, or by writing to Locke Department, General Electric Company, Post Office Box 57, Baltimore 3, Md.

(*Continued on page 54A*)

through 40 conductor miles in I-T-E Isolated Phase Bus

Metal-enclosed isolated phase bus was developed by I-T-E in 1936 to offer the highest degree of reliability and trouble-free operation for immense concentrations of power in limited areas. That it has more than achieved its objective is attested by the fact that I-T-E Isolated Phase Bus already carries 25% of the nation's power.

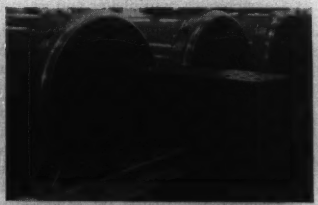
Among the 432 satisfied users are utility stations, industrial plants, and one of the world's largest hydro-electric plants.

Not only has I-T-E Isolated Phase Bus established an enviable record for economy in installation cost and performance, but its simple construction has adapted it to a wide variety of applications. It is being used indoors and outdoors, on short and long runs, along irregular building contours. Its welded sections, unitized for ease of handling, reduce costs on straight runs. Even complicated connections such as are often necessary in existing structures are provided for in standard I-T-E design. And it has other advantages. Its construction is sturdy and compact. It eliminates phase-to-phase faults. It uses porcelain in compression only. It affords a high degree of safety to operating personnel. It requires a minimum of maintenance. Factory-assembled lengths simplify installation, cut erection costs.

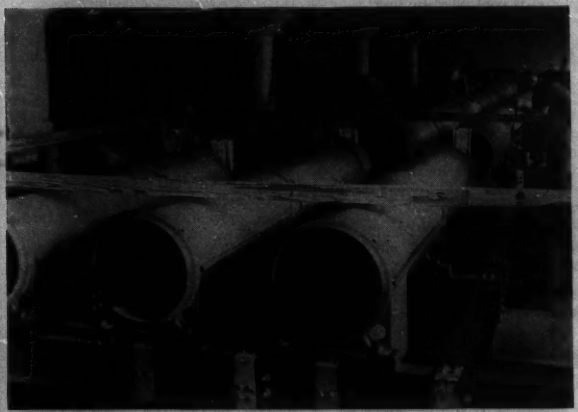
For more information about I-T-E Isolated Phase Bus, and how it can help you meet your modernization and expansion requirements more effectively, write for Bulletin 10004A, I-T-E Circuit Breaker Company, Switchgear Division, 19th and Hamilton Sts., Philadelphia 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY · Switchgear Division

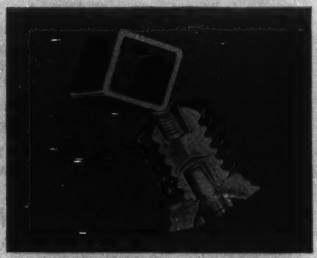
CONDUCTORS—one for each phase—are of copper or aluminum in round or square cross sections. Lengths up to 24 feet are joined end-to-end with solid, laminated or braided connectors.



SUPPORTING RINGS, of aluminum alloy, provide supports for insulators and connect the light metal cover electrically and mechanically to grounded steelwork. Tightly gasketed or welded aluminum covers make I-T-E Isolated Phase Bus suitable for indoor and outdoor use.

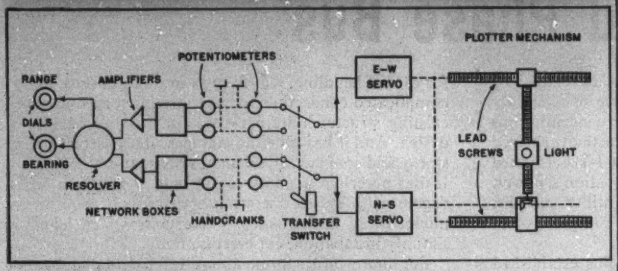


CONSTRUCTION of I-T-E Isolated Phase Bus is simple. It is a structure of copper conductors, one to a phase, each enclosed in its own grounded metal shield. This basic design not only completely eliminates phase-to-phase faults, but permits rapid erection of prefabricated sections delivered to the job ready to fit in place.



INSULATORS are of solid, nonaging porcelain, radially displaced to withstand compression. Insulators cradle conductors and allow free movement as the conductors expand and contract.

SINCE 1915 LEADERS IN AUTOMATIC CONTROL



Continuous Distance and Bearing Solutions with Unique Plotter-Resolver System

Problem: Determine automatically and continuously the distance and relative bearing of any two points on a map.

Ford Instrument's Solution: A combination of two standard components – a map plotter and an electrical resolver.

Result: Equipment can operate with maps up to a yard square – whose scale varies over a wide range. This means real flexibility because it does not restrict plotter just to maps – since photographs – even sketches can be used.

Here's how it works: The plotter proper has a smooth unobstructed glass top on which the map is placed. Under the glass there is a light traveling on screws. The screws are driven horizontally (E-W) and vertically (N-S) by servo motors actuated by a computing mechanism. The position of the light on the plotter is controlled by four handcranks. Two of the handcranks are used to position the light under the first point; a transfer switch is then thrown and the other two handcranks used to position the light under the second point. The map coordinates of the two points are algebraically added in two network boxes, the resultant voltage from the network boxes being the N-S and E-W distances between the two points. The resolver converts these two distances into range and bearing, which are indicated on two dials. Such a technique results in astounding accuracy. In a computer employing this principle, the maximum range error is on the order of one yard in a thousand, and the maximum bearing error is 10′. The average errors are about half the maximum.

If you have a problem in any phase of automatic control, it will pay you to discuss it with Ford engineers.

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(*Continued from page 50A*)

Multiplier Phototubes. "Du Mont Multiplier Phototubes," a catalogue of operational theory, data on applications, and specifications for standard and special multiplier phototubes, has been published by the technical sales department of Allen B. Du Mont Laboratories, Inc. The 64 pages of this illustrated catalogue have been divided into three sections. The first section contains a simplified technical discussion of photo and secondary emissions. The second section describes the utility of multiplier phototubes for the major sciences and industries. In the third section, full specifications on Du Mont standard and special multiplier phototubes are given, together with complete information on their accessories. Requests for this catalogue should be on company letterheads, and addressed to the Technical Sales Department, Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Avenue, Clifton, N. J.

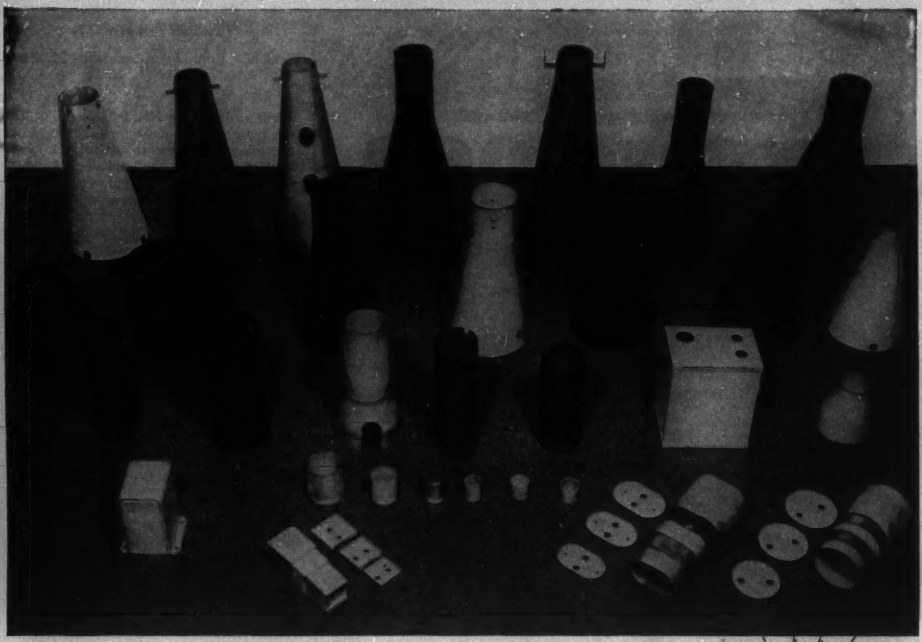
Bulletin on Photoelectric Controls. A new bulletin, "Proved Answers to Successful Automation," has been made available to industry by Photoswitch Division, Electronics Corporation of America. The 20-page illustrated pamphlet contains specifications, descriptive data, and operational charts of photoswitch photoelectric controls for numerous industrial uses. Copies of the bulletin may be obtained by writing Photoswitch Division, Electronics Corporation of America, 77 Broadway, Cambridge 42, Mass.

American Agile Catalogue. A 48-page general catalogue, illustrating and describing polyethylene and polyvinyl chloride fabricated products, plates, sheets, rods, tubes, pipes, and fittings, and hot gas welding and spraying equipment is now available from the American Agile Corporation, Post Office Box 168, Bedford, Ohio. The catalogue contains nearly 100 photographs, engineering drawings, sketches, reference charts, and tables. Copies of the literature may be obtained, without charge, from the American Agile Corporation, Post Office Box 168, Bedford, Ohio.

Molding Plaskon Alkyd Compounds. Proper tools, equipment, and techniques for best results with Plaskon alkyd molding compounds are covered in a revised 8-page booklet available from Barrett Division, Allied Chemical and Dye Corporation. Putty, granular and reinforced alkyds are discussed with specific recommendations made for each type of material. For a free copy of this booklet, write Barrett Division, Allied Chemical and Dye Corporation, 40 Rector Street, New York 6, N. Y.

Asbestos Textiles. "Asbestos Textiles," is an illustrated 16-page manual published by Johns-Manville. It covers asbestos lap, roving, yarn, cloth, tubing, cord, wick, rope, and tape. There is a page, or more, on each type of asbestos textile and the information includes photographs, drawings, and essential data in tabular form. Copies of "Asbestos Textiles" are

(*Continued on page 58A*)



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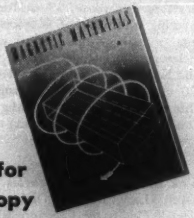

Write for your copy "MAGNETIC MATERIALS"

This 32-page book contains valuable data on all Allegheny Ludlum magnetic materials, silicon steels and special electrical alloys. Illustrated in full color, includes essential information on properties, characteristics, applications, etc. Your copy gladly sent free on request.

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Mumetal shields will give instant relief to interference caused by extraneous magnetic fields. This material can cure many troubles—solve many a problem for you.

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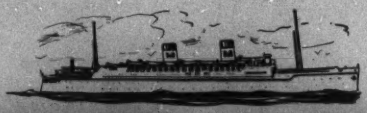

HYSOL 6000
goes to sea with RAYTHEON RADAR

The S. S. Lurline, one of the largest U. S. passenger liners, is the first big ship in the world to install Raytheon's new Model 1500 small boat radar. Scheduled for use as "standby" equipment, it will be used in conjunction with the regular 16-inch big ship "Mariners' Pathfinder" radar, shown in foreground and demonstrating comparative size. Chief Officer R. McKenzie inspects scope reading of the Model 1500.

HYSOL 6000 Epoxide Resins Used in Component Parts . . .

Complicated internal component parts of Raytheon radar equipment are formulated from HYSOL 6000 Series epoxide compounds because of their outstanding electrical and mechanical properties. In addition, HYSOL 6000 Series compounds provide a material which is economically molded into intricate shapes, including complicated inserts.

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The Raytheon application of HYSOL 6000 may suggest to you other plastic uses now posing a problem in your design or production departments. Houghton Laboratories, Inc., is ready to assist you with these problems through the experienced services of our skilled research laboratory, design and production departments. Your investigation will be welcomed at no obligation. Write, wire or phone today!

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(*Continued from page 54A*)

available from Johns-Manville, 22 East 40th Street, New York 16, N. Y.

Plant and Factory Noise Manual. With employee hearing-measurement programs becoming important to industry, a new booklet published by Employers Mutuals of Wausau proves both timely and informative. The manual furnishes training and reference material for those learning to operate audiometers to conduct pre-employment hearing measurements. Emphasis is placed on the techniques required in securing accurate data, and the proper method of recording findings obtained from the examinations. The manual, "Guide for Industrial Audiometric Technicians," may be obtained, without charge, by writing to: Accident Prevention Department; Employers Mutuals of Wausau, Wausau, Wis.

Philadelphia Gear Manual. The new Philadelphia Gear Manual includes 76 pages of illustrations, diagrams, definitions, tables, charts, and explanations regarding all types of gears. A simplified method of calculating horsepower ratings of all types of gearing is presented. For a copy of gear catalogue *G-655*, write to Philadelphia Gear Works, Inc., Venango and G Streets, Philadelphia, Pa.

Control Bulletin. General Electric's Limit-amp (registered trade-mark) high-voltage motor control is the subject of a new bulletin announced by the company's industry control department. Designated *GEA-6331*, the 2-colored publication outlines the features of the high-voltage current-limiting fused starters for co-ordinated control of squirrel-cage, synchronous, wound-rotor, and multispeed motors. Simplified installation and reduced space requirements are covered in the 12-page publication. It is available from the General Electric Company, Schenectady 5, N. Y.

Drafting Template. A drafting template, covering the line of Kaylock miniature nuts, is now available and will be sent, without charge, to those writing to: The Kaynar Company, Kaylock Division, 820 East 16th St., Los Angeles, Calif. This template covers all configurations, all sizes of anchor nuts, including the standard hex nuts and gang channel.

Cook Research Laboratories. Cook Research Laboratories, Division of Cook Electric Company, Chicago, Ill., has issued a 72-page brochure. This brochure, number *R-14*, goes into detail on organizational setup, and facilities for basic, applied, and development research in servomechanisms, nuclear physics, upper air studies, weather reconnaissance, radar, countermeasures, Sonar, guided missiles, air-borne electronic instruments, air-borne fire control systems, electronic instrumentation, human engineering, and general electromechanical developments. Included is a description of the types of work carried on by the

(*Continued on page 62A*)

Oil Immersed

HIGH VOLTAGE ACROSS-THE-LINE AND REDUCED VOLTAGE CONTROL OF CUBICLE CONSTRUCTION

Standard units consist of: insulated round bus with terminals for incoming line; low voltage control transformer; current limiting, high interrupting capacity fuses; quick acting, heavy duty contactor with non-freezing contacts; magnetic overload relays with instantaneous and inverse time element electrically reset; sealed-off motor terminal compartment; low voltage control center; self-contained tank lowering device; electrical and mechanical door interlock. Additional features such as watt-hour meter, voltmeter, ammeter, potential switch, etc., may be provided to meet the requirements of specific applications. These self-contained, self-supporting control units are designed for single or group mounting—for indoor or outdoor service.

ABOVE — Type 700-B, high voltage combination starter of Cubicle construction.

RIGHT — Group mounting of high voltage Cubicles shown in actual use.

ROWAN CONTROL

DALOHM now presents ® America's Finest

Collet-fitting KNOBS

Dalohm design permits positive locking on all standard shaft diameters full round or flatted with no damaging effect so frequently found when using set-screw type knobs.

FIVE SIZES ⅜" 1 1/16" 1¾" 2¼" 3"

COLLETS INTERCHANGEABLE . . . accommodate all shaft sizes from ⅛" to ⅜"

- Precision cast of thermo setting plastic in easy grip shapes. Pleasing appearance to match modern styling
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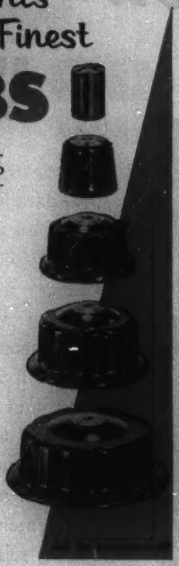

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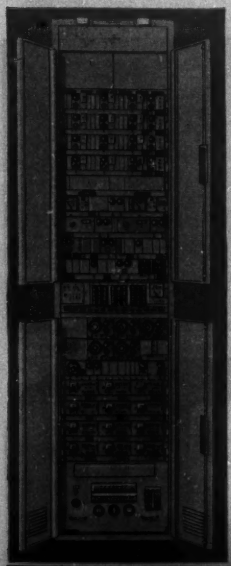

TWELVE-CHANNEL OPEN-WIRE LONG-HAUL CARRIER-TELEPHONE SYSTEM OF ADVANCED DESIGN

This is a 12-channel 2-wire single-sideband carrier-suppressed miniaturized plug-in equipment operating in the band 36 to 143 kc. Six frequency allocations are available. Channel bandwidth is 300 to 3400 cycles. Three of the voice channels may be replaced by a 10-kc program channel. Built-in ringing and dialling facilities are available. Maximum attenuation per repeater section is 74 db and full automatic regulation of transmission variations is provided. Either frogging or non-frogging repeaters are used, and systems of any length can be set up to meet standard toll-transmission requirements, with adequately engineered lines.

This system is assembled from a series of standardized equipment units, which are employed to form universal carrier-telephone systems of from three to 960 channels. Information on these systems will be furnished on request.

Type T12 Terminal complete with test equipment mounts on one side of an 8' 6" bay.

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(*Continued from page 58A*)

various sections, also examples of research and development work on some of the unclassified projects. Copies of this brochure may be obtained from Cook Electric Company, 2700 Southport Avenue, Chicago 14, Ill.

Applications and Design Ideas. More than 25 design applications of the Neg'ator constant-force spring are described and illustrated in a 2-color 16-page technical bulletin published by Hunter Spring Company. Suggestions to facilitate the design of Neg'ator springs and motors are included in the bulletin, and an application worksheet is enclosed as a convenience to the designer. Sample Neg'ator springs and motors, intended to aid engineers in the solution of specific design problems, are also covered. Bulletin *310N* may be obtained, without cost, from Engineering Department, Hunter Spring Company, Lansdale, Pa.

Handbook of Industrial Heating. A 20-page handbook designed to provide plant management and engineers with basic concepts of industrial heat processing and heat control is being distributed on request by the Michigan Oven Company. The heat handbook discusses heat-to-fuel cost comparisons to design elements. For a copy of the MOCO "Fact Book" write: Michigan Oven Company, 415 Brainard, Detroit 1, Mich.

Insulation Booklet. A 12-page booklet, explaining the advantages of Thermalastic (registered trade-mark) insulation, is available from the Westinghouse Electric Corporation. The ten properties of Thermalastic insulation are discussed. The booklet also contains a short, illustrative story on how Thermalastic insulation was developed. For a copy of this booklet, *B-6506*, write Westinghouse Electric Corporation, Post Office Box 2099, Pittsburgh 30, Pa.

Milliohmeters and Microhmeters. Ten milliohmeters and microhmeters for measuring low resistances between 0.0001 ohm and 100 ohms are described in Engineering Bulletin *L-39*, prepared by the Shallcross Manufacturing Company, Collingdale, Pa. Complete electrical and mechanical specifications on all instruments and accessories are shown in Bulletin *L-39*, a copy of which is available on request.

Electrical Laminations Bulletin. Bulletin number *L-355* on electrical laminations has been released by Thomas and Skinner Steel Products, Inc., Indianapolis, Ind. The 40-page bulletin, through product line drawings, graphs, and charts, provides full information on special, standard, and *MIL-T* Thomas and Skinner electrical laminations. A copy of the new "Electrical Lamination Bulletin number *L-355*" may be obtained by writing to Thomas and Skinner Steel Products Company, Inc., 1154, Indianapolis, Ind.